THE SOUTHWESTERN NATURALIST

VOLUME 3, NO. 1–4 1958 (PRINTED 1959)

THE SOUTHWESTERN ASSOCIATION OF NATURALISTS

President

CARL D. RIGGS *(Ichthyology)*
University of Oklahoma

Vice President

GEORGE A. MOORE *(Ichthyology)*
Oklahoma State University

Secretary-Treasurer

R. W. STRANDTMANN *(Invertebrate Zoology)*
Texas Technological College

Editor

LLOYD H. SHINNERS *(Botany)*
Southern Methodist University

Board of Governors

Class of 1959

ALBERT P. BLAIR *(Herpetology)*
University of Tulsa

DOROTHY V. LEAKE *(Phycology)*
Southeastern (Oklahoma) State College

Class of 1960

W. HOWARD MCCARLEY *(Mammalogy)*
Stephen F. Austin State College

MARSHALL R. WHEELER *(Insect Taxonomy)*
University of Texas

Class of 1961

GEORGE H. BICK *(Entomology-Limnology)*
Southwestern Louisiana Institute

ROBERT G. LINDEBORG *(Animal Ecology)*
New Mexico Highlands University

Class of 1962

ROBERT F. CLARKE *(Herpetology)*
Kansas State College at Emporia

B. L. TURNER *(Plant Taxonomy)*
University of Texas

Founded in May, 1953, "to promote the field study of plants and animals, living and fossil, in the Southwestern United States and Mexico, and to aid the scientific activities of its members," the Association holds an annual meeting with field trips, issues a newsletter, SWANEWS, and publishes THE SOUTHWESTERN NATURALIST. Membership is open to all persons interested in the natural history of Arizona, Arkansas, Kansas, Louisiana, New Mexico, Oklahoma, Texas and Mexico. Application should be made to the Secretary-Treasurer. Dues are $2 per year for regular members, $4 for sustianing members.

THE SOUTHWESTERN NATURALIST

Published by The Southwestern Association of Naturalists, four times a year, at Dallas, Texas. Subscriptions to members, $3 per year (in addition to dues; payable with dues directly to the Secretary-Treasurer); to non-members, $5 per year (enter non-member subscriptions with the Secretary-Treasurer, making checks or money orders payable to The Southwestern Association of Naturalists). Single issues are not sold separately. Publication is not available in exchange.

THE SOUTHWESTERN NATURALIST 3: 1–6 1958 (PRINTED 1959)

MAN AS A DISPERSAL AGENT[1]

F. R. FOSBERG

Pacific Vegetation Project, c/o National Research Council, Washington 25, D.C.

ABSTRACT. Evolution of means of crossing barriers and discontinuities between suitable habitats has been a characteristic of plants, resulting in various and highly ingenious dispersal mechanisms. Most of these are adaptations to take advantage of different dispersal agents. Prominent among these agents are animals, of which man has, at least in recent time, been the most effective. Certain plants have evolved so far in this direction as to become entirely dependent on man for their dispersal. Most of these are cultivated plants, deliberately carried around by man. Some are even reproductively sterile. That this is a highly successful adaptation is shown by the wide distribution and enormous numbers of individuals of certain man-carried species.

The effects of man's activities as a dispersal agent are various. Species have disappeared and other new ones have come into existence as a result. Floras have been confused and the natural distribution patterns obscured. Additional variable factors have been added to an already complex situation. Perhaps an additional result of this is the well-known aversion of so many botanists to the study of cultivated plants and other taxonomic and vegetational situations dominated by man.

The dispersal of plants and animals is a subject that has been written on by many able students and about which an enormous literature has grown up. To review even the part of this related to man would be manifestly impossible in the time allotted. Therefore it seems best to attempt only to present some of my own knowledge, experience, and ideas to stimulate discussion, and furthermore, to limit myself to plant dispersal, on which obviously I speak with more authority. Certain of the observations would apply also to animals, but their possession of means of voluntary motility alters the problem very considerably.

There is a direct relationship, long apparent to naturalists, but made more and more clear by modern biosystematic studies, between the diversity of plants, variously estimated at between 200,000 and 500,000 species and countless lesser forms, and the mosaic of different habitats and environmental niches found in the world. Plant taxa have evolved adapted to almost every conceivable habitat or niche.

Since these habitats are seldom continuous, plant species have survived changes by developing means of getting across the intervening spaces or barriers. Their often ingenious apparatus for accomplishing

[1] Talk given at the Missouri Botanical Garden's Fifth Annual Symposium on Systematics, St. Louis, 25 October 1958.

this are referred to as dispersal mechanisms. Since the motility of plants or their diaspores under their own power is, at best, extremely limited, most dispersal mechanisms are adaptations to take advantage of external means of transport, termed dispersal agents. The effectiveness of these means of dispersal may be measured, in part, by the degree to which species are actually found in the situations where they are able to establish themselves and grow. That natural means of dispersal are not all 100% effective is suggested by the cases in which exotic plants have naturalized themselves after introduction into new habitats by man. Consideration of this naturalization is complicated, however, by the great disturbance of habitats brought about by man's activities. This includes the creation of new habitats and the modification, expansion and contraction of old ones. One of the difficulties in evaluating man's role and effectiveness as a dispersal agent is to separate the effects of his direct activity in dispersal from his indirect function in plant distribution through his influence on habitat. The latter effects are major in extent and importance and have been dealt with in other parts of the symposium. Here we should try to confine ourselves to the relation of man to the actual transportation of plants or their diaspores from one place to another.

Some very fancy terminology has been devised to express classifications of plants based on their means of dispersal. A current system of dispersal types (Molinier and Müller, 1938, as modified by Dansereau and Lems, 1957) divides plants into six self-explanatory categories:

I. Barochores (dispersed by gravity)
II. Hydrochores (dispersed by water)
III. Anemochores (dispersed by wind)
IV. Zoochores (dispersed by animals)
V. Anthropochores (dispersed by man)
VI. Autochores (dispersed by their own mechanisms).

These are clearly not mutually exclusive. We are obviously concerned here with category V.

Anthropochory is, of course, only a special class of zoochory. In spite of the recent demonstration of the possibilities of extremely rapid evolution, it is clear that a vast number of plants that are dispersed by man evolved their dispersal mechanisms long before man became a factor of importance in carrying plants around. Man is merely functioning as another animal when he eats a fleshy fruit and rejects its indigestible seed, or when a burr or other adherent fruit clings to his hair, clothing or implements and is thereby moved from one place to another. There is no doubt, however, that he is in some instances many

times more effective than most animals in accomplishing long distance transport.

True anthropochory, as distinct from these cases of ordinary zoochory with man as the animal agent, are principally found among cultivated plants: those which were either originally especially useful to man, or have become so by deliberate selection or breeding. Species and even genera have apparently been brought into being this way, so distinct that we are not even sure what their wild ancestors were. Others, not usually called distinct species, are so different that, were not the facts of their origins known, they would doubtless be placed in separate species, or even genera. These man-made taxa are usually entirely dependent on man for their dispersal. Judging by the extent of their ranges and the numbers of individuals in existence, many of them must be regarded as eminently successful organisms, with dependence on man as a very effective means of dispersal.

The types of adaptation (including the more obvious dispersal mechanisms) effective in bringing about dispersal by man are numerous. Most of them may be arranged in relatively few general categories as follows:

1. Seeds or fruits viscous or equipped with hooks, barbs, or other means to secure accidental transport on man's body, clothing, or implements.
2. Vegetative parts of plant, capable of taking root and establishment, carried accidentally by man or his implements.
3. Seeds so small that, even without special mechanisms, they adhere to man or his implements or to mud or other substances adherent to him or his implements.
4. Edible fleshy fruits and other parts with or without inedible seeds.
5. Edible seeds, nuts or grains.
6. Edible stems, leaves, roots and other vegetative parts. (Edibility in 5 and 6 either to man or to animals of interest to him.)
7. Edible or otherwise useful oils and essences.
8. Useful fibers and sources of cellulose.
9. Useful woods.
10. Drugs and other useful chemical components or products.
11. Capacity to ferment or otherwise modify other substances.
12. Showy or aesthetically pleasing flowers, fruits, bracts, leaves, or growth habit.
13. Curious or bizarre forms.
14. Ability to stabilize or modify certain environmental factors—

e.g. to produce shade, to bind sand, to inhibit erosion, to fix nitrogen, etc.

15. Habit of growing in cultivated ground, so that accidental transport with cultivated plants and nursery stock is frequent, or at least may happen.

16. Parasitism on plants otherwise transported by man.

Other categories could likely be thought of, or some of those listed here might logically be combined. Some cases are not easily classified; for example, plants brought into botanical gardens merely to have representatives of particular groups, though they are neither useful nor ornamental. Then there are the multitudes of plants deliberately carried around for no apparent reason whatever.

There are, in the older centers of human activity, some wild species or varieties of wild species, that have, over a long period, become adapted to life in the company of man, either in his cultivated fields and gardens, or in his nitrogen-rich waste places and rubbish heaps. These should be mainly considered in other papers, but they do seem to possess effective means of following man around, either carried by him or by other means. They would logically fit into category 15, above.

There remain to be considered the effects of the activities of man as a dispersal agent. These are largely very obvious. Almost anywhere may be seen plants that originated in all parts of the earth. The majority of exotics in any one place are from regions of similar climate, but even climatic lines are transgressed. Witness the multitudes of tropical species raised in temperate or even cold climates as house plants or in greenhouses.

In the total flora of almost any locality inhabited or influenced by man a substantial proportion of the species are exotic. Many of them are effectively naturalized, many dependent on man for their continued presence, some merely temporary waifs. Of the latter continued reintroduction may take place until a biotype is brought in that is adapted to an available local habitat and the species then may become naturalized. Or this may never happen.

Man has, as is well known, brought about the disappearance of many species. This extinction, local or general, is not, of course, entirely or even principally the result of man's dispersal activities, but much of it is. Competition with introduced species is undoubtedly a major factor in the increasing rarity or disappearance of many pioneer species, and possibly even of some members of more mature communities. A somewhat more strained example would be plants which disappear be-

cause their habitats are taken over by cultivation of introduced crop plants. The introduction of exotic plant disease organisms or insects that damage plants is at least a factor in the extinction or reduction of some plant species. I do not know of an example of a plant completely wiped out by such an occurrence, but the American chestnut and the Bermuda juniper are no longer important components of vegetation types in which they were formerly dominant, following introduction of a disease and an insect, respectively. The proportions, if not the exact composition, of vegetation is highly modified in such cases. In the case of the several extinct Hawaiian drepanid birds, introduced disease organisms are credited by some authorities with responsibility for their disappearance. Perhaps the most certain instances that belong here are the plants and animals that have disappeared as a result of man's propensities in dispersal of goats to isolated islands. Though such results are in a sense indirect, man cannot escape the responsibility for the losses that are consequences of the activity of the goats.

Over long periods this dispersal of plants by man has gone on until original patterns of distribution have sometimes become obscured. The actual original homes of some species are not known or are matters of some dispute or uncertainty. Plants may continue to exist in places where they were taken by man after they have disappeared from their original homes—e.g. *Franklinia.*

Finally, as a direct result of dispersal of certain species by man, new species may come into existence. A few documented cases among wild plants exist, such as the well-known *Spartina townsendii*, result of hybridization between an introduced American species and a native European species, followed by amphidiploidy. Many others doubtless exist which have not been proven yet. Similar phenomena are well known among cultivated plants. The cultivated American cottons, for example, are thought to have originated in this way. The whole art of plant breeding depends on the bringing together of suitable related plants, usually from different places. The extreme form of this process may be the transport of pollen, as in orchid culture, from a plant growing in one locality, to pollinate a plant growing in another.

Most of these dispersal processes in plants correspond to similar ones among animals. Even the transport of pollen is matched by transport of sperm in animal breeding.

In conclusion, the evidence seems to indicate that man is by far the most effective dispersal agent that ever has existed. His influence on the floras of the world during only the last 500 years has been greater than that of any other single agent in many times that length of time.

His influence on the vegetation of the world has been greater than that of all other agents combined. A detailed consideration of his actual activities as a dispersal agent or of their consequences would be a major project, rather than a subject for a fifteen minute talk.

LITERATURE CITED

DANSEREAU, PIERRE, and KORNELIUS LEMS. 1957. The grading of dispersal types in plant communities and their ecological significance. Contrib. Inst. Bot. Univ. Montréal No. 71. 52 pp.

THE SOUTHWESTERN NATURALIST 3: 7–12 1958 (PRINTED 1959)

FIRE ANTS, HEPTACHLOR, AND FISH KILL

JACK BOUDREAUX, KIRK STRAWN, AND GERALD CALLAS

Department of Biological Sciences, Lamar State College of Technology, Beaumont, Texas

ABSTRACT. Twenty pounds of 10 per cent heptachlor were applied per acre on the northern half of the Fralise Farm near Sour Lake, Texas. Fish kill was heavy and continued for over three weeks. Young fish died first. The few survivors were usually large and, except for shad and gambusia, were thin. Two months after the poisoning, larvae of several species were found, and the population of fishes appeared to be on the way to recovery. During a later treatment of the southern part of the farm, extreme care was taken to avoid contamination of water with heptachlor. Fish kill was avoided.

The imported fire ant, *Solenopsis saevissima richteri* Forel, has become a major pest in the Gulf Coast states. The Agriculture Research Service, Plant Pest Control Division of the Department of Agriculture is planning an eradication program which would cover much of the Austroriparian Biotic Provence with insecticides. The Fralise Farm, a cattle and rice unit partially filling the triangle between State Highway 105 and Farm Road 326 northeast of Sour Lake, Hardin County, was chosen for the first major application of poison in Texas. Granular 10 per cent heptachlor was applied at the rate of 20 ponds per acre. Heptachlor, selected because of its relatively low cost, is effective against fire ants for three to five years.

Numerous fishes lived in a small stream, which bisects the farm into northern and southern halves, and in a network of canals and ditches which irrigates and drains the rice fields. It was expected that the poison would have a severe effect on fishes. We determined the effect by making extensive collections, by means of a twenty-foot common sense seine, before and after the poison was administered, and by frequent inspections for dead and dying fishes. The duration of this study was 15 February to 5 June 1958.

M and M Air Service of Nome, Texas, began treating the area north of the stream with duster aircraft 3 March at 6:30 A.M. and completed poisoning on the fourth. Livestock were moved to the southern half of the farm to protect them from the heptachlor prior to the application of the poison. About two weeks later they were moved back to the north side. Application of insecticide on the south side was delayed until 13 May. When the north side was treated, water standing in rice

fields, minor ditches, and the stream was not protected. Care was taken to keep aerial application away from the major irrigation canal, but some heptachlor drifted in. Crews of laborers treated the banks with hand seeders.

Four major habitats were checked on the north side. The first consists of a three- to fifteen-foot wide irrigation canal about two miles long. It is fed by a deep-well pump and is divided into sections by locks which control the water level. It is used to flood rice fields and to water cattle. The assortment of fishes in this habitat may be influenced by seasonal inflow of clear deep-well water. Only turbid surface run off was in the canal until 23 March at which time the ditch was flushed with well water. The upstream sections are shallow and the downstream sections reach a depth of five feet. The species of fishes found in this canal were:

Gizzard shad, *Dorosoma cepedianum* (LeSueur); redfin pickerel, *Esox americanus* Gmelin; lake chubsucker, *Erimyzon sucetta* (Lacépède); golden shiner, *Notemigonus crysoleucas* (Mitchill); pugnose minnow, *Opsopoeodus emiliae* Hay; black bullhead, *Ictalurus melas* (Rafinesque); golden topminnow, *Fundulus chrysotus* Holbrook; gambusia, *Gambusia affinis* (Baird and Girard); pirateperch, *Aphredoderus sayanus* (Gilliams); largemouth bass, *Micropterus salmoides* (Lacépède); warmouth sunfish, *Chaenobryttus coronarius* (Bartram); bantam sunfish, *Lepomis symmetricus* Forbes; longear sunfish, *Lepomis megalotis* (Rafinesque); bluegill sunfish, *Lepomis macrochirus* Rafinesque; black crappie, *Pomoxis nigromaculatus* LeSueur; white crappie, *Pomoxis annularis* Rafinesque; and slough darter, *Etheostoma gracile* (Girard). Few rough fish were taken. Prior to the poisoning, the canal was heavily populated with fat forage and game fishes. Warmouth, longear sunfish, and bluegill were abundant. Largemouth bass, white and black crappie, and gizzard shad were taken only in the deeper sections. Golden shiners, gambusia, and slough darters were most abundant in the shallow upstream stations. The only sucker (lake chubsucker) collected came from a deep section.

The poisoning of this canal was accidental. Some heptachlor drifted in from the aerial treatment and the men with the hand seeders may have been careless. White granules of insecticide could be seen on the ditch bank; a heavy rain following treatment probably washed many of these granules into the water. Some poison may have floated in with water draining from the rice fields. Observations the afternoon of the first poisoning revealed no effect on the fish, but numerous sick

insects and spiders were noticed. Three days later golden shiners, black bullheads, gambusia, and small centrarchids were seen dead and dying.

Surface commotion drew attention to the affected fishes. They reacted in one of three ways: they either swam to the surface and repeatedly thrust their heads out of the water, swam in tight circles, or swam in a straight line in wild dashes. On occasion, gizzard shad, black bullheads, and sunfishes were seen fighting to get out onto the banks. This appeared to be the ultimate aim of the affected . . . To get out of the water.

By 10 March, fishes, up to five inches in length, were dead along most of the canal bank. Small, particularly young fishes, died first. With the passage of time, progressively larger fishes died. On 14 March, a seven-inch-long shad and sunfishes over five inches long were dead. Seining on 15 March produced few young fishes and the fishes caught were thin. The poor condition of these fishes could either be a direct effect of the poison or caused indirectly by the destruction of crustaceans, insects, and fishes used for food. Fishes dying from the poison were invariably thin. Starting on 23 March, the supervisors of the farm flushed the canal with deep-well water for three days. They were afraid of possible lethal effects resulting from their registered cattle's drinking the water that had proved so deadly to fishes. A heavy kill of birds and small mammals (Lay 1958) reinforced their fear. No dead fishes were observed after this date. As deaths ceased in all habitats within a week, fish kill would probably have ended in the canal without the flushing.

Half a day was spent collecting in the canal on 4 May, two months after the application of heptachlor. This collection yielded the only pickerel and pirateperch caught in the canal. Young fishes, which were abundant prior to the poisoning, were not found. The few survivors were large but not plump, except for the shad and gambusia. Female gambusia were swollen with embryos, but no adult males were found. The slough darter was the only formerly abundant species missing. The poisoning, which occurred during its breeding season, probably would have been as toxic to darter fry as it was to other young fishes. Adult slough darters are difficult to find at the end of the breeding season. In most places, this darter is probably an annual, so lack of adults may not have been a result of the poisoning. Larvae of shad, golden shiners, gambusia, bass, and sunfishes were present on 4 May. The canal appears on its way to recovery and prospects appear excellent that the heptachlor will not have a three- to five-year detri-

mental effect on fishes as is claimed for fire ants, unless the food supply continues to be diminished by the poison.

The second habitat consisted of shallow water standing in depressions in fallow rice fields. Gambusia and bantam sunfish were the abundant species. In the two areas checked, kill was 100 per cent. No effect was noticed on tadpoles.

The third type of habitat consisted of small ditches draining the poisoned areas. Kill was severe, but living fishes were found wherever a seine was used. The last dying and recently dead fishes were seen in the stagnant end of a roadside ditch on 30 March. This lot consisted of a yearling largemouth bass and several gambusia.

The fourth major habitat consists of a small snag-filled, sand-and-silt-bottomed stream ranging from two to ten feet wide and averaging from two inches to about a foot deep. Following rains it is much larger. This stream received poison directly from the airplanes and indirectly from water draining from the rice fields. Polution from an upstream oil field undoubtedly influences the occurrence and abundance of fishes. During floods, oil escapes to the stream from oil pits. The presence of striped mullet, *Mugil cephalus* Linnaeus, may indicate salt pollution. The prepoisoning collections were made during a period of heavy rain and the collections two months after poisoning were made during a dry spell. Species taken in this stream were:
Redfin pickerel, *Esox americanus;* lake chubsucker, *Erimyzon sucetta;* golden shiner, *Notemigonus crysoleucas;* pugnose minnow, *Opsopoeodus emiliae;* ribbon shiner, *Notropis fumeus* Evermann; redhorse shiner, *Notropis lutrensis* (Baird and Girard); spottail shiner, *Notropis venustus* (Girard); weed shiner, *Notropis roseus* (Jordan); silvery minnow, *Hybognathus nuchalis* Agassiz; bullhead minnow, *Pimephales vigilax* (Baird and Girard); channel catfish, *Ictalurus punctatus* (Rafinesque); yellow bullhead, *Ictalurus natalis* (LeSueur); black bullhead, *Ictalurus melas;* tadpole madtom, *Schilbeodes gyrinus* (Mitchill); golden topminnow, *Fundulus chrysotus;* gambusia, *Gambusia affinis;* pirateperch, *Aphredoderus sayanus;* striped mullet, *Mugil cephalus;* largemouth bass, *Micropterus salmoides;* warmouth sunfish, *Chaenobryttus coronarius;* green sunfish, *Lepomis cyanellus* Rafinesque; bantam sunfish, *Lepomis symmetricus;* redbreast sunfish, *Lepomis auritus* (Linnaeus); longear sunfish, *Lepomis megalotis;* bluegill sunfish, *Lepomis macrochirus;* dusky darter, *Percina sciera* (Swain); bluntnose darter, *Etheostoma chlorosomum* (Hay); slough darter, *Etheostoma gracile;* and cypress darter, *Etheostoma proeliare* (Hay). The variables in this stream make assessment of the effect of

heptachlor on the fishes difficult. Two stations were collected. One was downstream from the western border of the farm where the stream flows through an open pasture. Eighteen species were caught in the prepoisoning collection and ten occurred in the collection made on 4 May. Two of the species taken in the second collection were not present in the first collection. The stream was collected in a canopied area upstream from its exit from the poisoned area. Nineteen species were collected prior to the poisoning and sixteen on 4 May. Four of the species found in the later collection were not found in the former.

The poison may have been responsible for the disappearance of species from the stream or the change may be an artifact of collecting. Darters and small sunfishes were rare in 4 May collections. In contrast to the canal, male gambusia survived. Small dead sunfishes were observed in the drift along the stream on 7, 8, 10, and 14 March. These could have been either residents of the stream or washed in from drainage ditches. One dead striped mullet, probably a resident of the stream, was found.

The south side of the farm was treated 13 and 14 May, both aerially and by hand. Extreme care was taken to avoid all water. The airplanes left untreated two swath widths bordering a farm pond, irrigation canals, drainage ditches, watering holes, and the stream. Hand seeders were used on these two swath widths, but no poison was applied close to the water. In contrast to the north side, the poison was applied when the ground was relatively dry. Few, if any, fishes were present in the rice fields which received the poison. Although we did not check the south side until 5 June, we believe fish kill was slight. All sizes of fishes appeared abundant and no sign of dead or sick fishes was found. Dan Lay, State Research Biologist, and Billy Weston, farm foreman, believe there was little, if any fish kill.

From our investigation, it appears that care must be taken to keep heptachlor away from water to prevent severe damage to fish populations. An ill-supervised fire ant control program could result in at least temporary poor fishing and in the local extermination of some species throughout the Gulf Coast states.

We are most grateful to Mr. Ray Edmondson, manager, and Mr. Billy Weston, foreman, of the Fralise Farms, Incorporated, for facilitating our investigation. Mr. C. B. Williams, Beaumont District Leader, Plant Pest Control Division, U.S.D.A., has provided information on the fire ant control program. Mr. Dan Lay, State Research Biologist, Buna, Texas, has given freely of his extensive observations on the effect of heptachlor on the fishes, birds, and mammals. Drs.

George A. Moore and Royal D. Suttkus have aided in the identification of fishes. Dr. George A. Moore has criticized the manuscript.

LITERATURE CITED

LAY, DAN. 1958. Count three for trouble. Texas Game and Fish 16(7): 4–7.

THE SOUTHWESTERN NATURALIST 3: 13–16 1958 (PRINTED 1959)

FLUCTUATIONS OF SOME CENTRAL TEXAS FISH POPULATIONS

CLARK HUBBS AND WILLIAM F. HETTLER

Department of Zoology, University of Texas, Austin 12

ABSTRACT. The relative abundance of fishes at specific central Texas localities usually is more or less constant. Notable exceptions include: replacement of *Gambusia geiseri* by *Notropis venustus* and *N. amabilis* in the South Concho River; the disappearance of *Hadropterus scierus* in the Guadalupe River in Kerr County; and the drastic reduction in *Etheostoma spectabile* populations in the Colorado River in Austin and consequent increase of *E. lepidum* and *E. chlorosomum* populations. The variations are correlated with known changes in stream ecology.

The relative abundance of fish species at a specific locality has been checked. Due to the absence of extensive early collections, most of the comparisons are among populations sampled between 1949 and 1958. Most fish populations maintain approximately the same relative abundance; however, there are some notable exceptions. Some of the fluctuating populations are discussed and the changes are correlated with environmental factors.

Many faunal reports are based on collections obtained during a short interval, usually one season. Such reports by necessity not only may overlook rare species, but also may give the wrong impression of the relative abundance of species whose populations are high or low at the time of the survey. Gunter (1945) Merriman (1947) and others have reported on population changes at specific localities; however, most of these concern seasonal or tidal changes. Our report, like that of Trautman (1957) concerns population changes that are not seasonal. Some of the changes may be due to chance; however, most can be correlated with environmental changes. Others, such as the collection of *Dionda diaboli* (Hubbs and Brown) by R. D. Suttkus from San Felipe Creek where previous collectors had not obtained any individuals, may be due to superior collecting technique (Hubbs and Brown, 1956).

Several stations on the Guadalupe River in eastern Kerr and western Kendall counties have been sampled more than 20 times. During 1951, *Hadropterus scierus* Swain was present in most collections east of Kerrville (Hubbs, Kuehne, and Ball, 1953). By 1954 specimens

were no longer obtained in Kerr County and since that date none have been taken in Kendall County. This interval corresponds with reduction of stream volume during the recent drought. As this species is not taken from smaller streams in central Texas, reduction in flow probably is responsible for its decrease in abundance.

The South Concho River 4 miles south of Christoval, Tom Green County, has been sampled several times between 1953 and 1958. The abundance of *Etheostoma lepidum* (Girard) correlates inversely with the amount of scouring of the channel by recent floods (Strawn, 1957). During the first visits specimens of *Campostoma anomalum* (Rafinesque) frequently were collected. In later collections after the suspected introduction of *Astyanax faciatus* (Cuvier), the *Campostoma* population was low. *Gambusia geiseri* Hubbs and Hubbs was extremely abundant in several collections both before and after *A. fasciatus* became abundant. The locality was visited during November, 1957, and May, 1958, and few *G. geiseri* were obtained. Seine hauls which previously had yielded more than a quart of this small fish never contained more than two individuals. The same seine hauls often contained one to two quarts of *Notropis venustus* (Girard) and *N. amabilis* (Girard). These two shiners had been rare or absent in previous collections. Drought conditions prior to 1957 had reduced or eliminated the river upstream from the sampling station. Most or all of the water volume came from the large spring at that site. Wetter climatic conditions in 1957 increased surface run off and the upper springs contributed more than ½ of the stream flow. It is not surprising that a spring inhabiting species was replaced by typical central Texas stream fishes.

The Colorado River in Austin has been sampled repeatedly at all seasons for 10 years. Much of the collecting has been carried out in the rapids to obtain darters for experimental work. Prior to 1952 only 11 specimens of *Hadropterus scierus* were obtained despite extensive efforts to obtain comparative material for racial studies (Hubbs, 1954a). Since 1955 single collections containing more than 20 individuals have been obtained frequently. As upstream reservoirs permitted maintenance of a more or less constant flow until 1957, stream volume fluctuations are not thought to have effected the population frequency. During 1954 and 1955 almost all collections from the Colorado River in Austin contained specimens of *Phenacobius mirabilis* (Girard) (Hubbs and Herzog, 1955). Collections in Austin before and after that date have not contained any specimens, although they have been obtained elsewhere in the river. Again no ecologic factors are known that might be correlated with population frequency.

On February 16, 1958, one specimen of *Ethoestoma lepidum* (Baird and Girard) and two of *Etheostoma chlorosomum* (Hay) were collected from the Colorado River in Austin. Only Jordan and Gilbert's (1886) specimens of *E. lepidum* from Barton Springs are known from Travis County (Hubbs, 1954b, Strawn, 1957) despite extensive collecting. Only three specimens of *E. chlorosomum* have been obtained previously from the Colorado River in Austin. Only one individual of *E. spectabile* (Agassiz) was obtained in the same collection. Previous collections had shown that species to be the dominant fast-water bottom fish there (Hubbs, 1957). *Etheostoma spectabile* inhabits moderately swift shallow riffles with small to medium-sized rocks (Hubbs and Strawn, 1957). Until 1957 much of the fast water in the Colorado River in Austin fit this description. After the heavy rains water volumes in the river in Austin were constantly high during the last half of the year. Typical *E. spectabile* riffles were covered with 5 to 15 feet of fast moving water. It is likely that this adverse habitat reduced the *E. spectabile* population to minimal levels. Therefore this nitch was essentially unoccupied. This may have permitted expansion of *E. lepidum* and *E. chlorosomum* populations into habitats previously exclusively occupied by *E. spectabile*. In 1958 subsequent collections also include equal numbers of the three species. During 1959 *E. spectable* became rather abundant and *E. lepidum* individuals were frequently captured.

In addition to these more or less natural population fluctuations, many others have been documented that correlate with the known or suspected introduction of the fish into foreign waters, such as those described by Brown (1953).

The changes in abundance of a species in a specific locality parellels those given for Ohio fishes by Trautman (1957) except that his changes usually involve a longer time interval and greater distance. This clearly points out the hazard of definite zoogeographic conclusions derived from negative data on minimal collections.

ACKNOWLEDGMENTS

We wish to thank the many individuals who have collected specimens discussed in this paper.

LITERATURE CITED

BROWN, WILLIAM H. 1953. Introduced fish species of the Guadalupe River Basin. Tex. J. Sci. 5: 245–251.

GUNTER, GORDON. 1945. Studies on marine fishes of Texas. Pub. Inst. Mar. Sci. Univ. Texas 1 (1): 1–190.

HUBBS, CLARK. 1954a. A new Texas subspecies, *apristis*, of the darter *Hadrop-*

terus scierus, with a discussion of variation within the species. Am. Midland Nat. 52: 211–220.

———— 1954b. Corrected distributional records for Texas fresh-water fishes. Tex. J. Sci. 6: 277–291.

———— 1957. Distributional patterns of Texas fresh-water fishes. Southwestern Nat. 2: 89–104.

HUBBS, CLARK, and WILLIAM H. BROWN. 1956. *Dionda diaboli* (Cyprinidae), a new minnow from Texas. Southwestern Nat. 1: 69–77.

HUBBS, CLARK, and WILLIAM F. HERZOG. 1955. The distribution of the suckermouth minnow, *Phenacobius mirabilis*, in Texas. Tex. J. Sci. 7: 69–71.

HUBBS, CLARK, ROBERT A. KUEHNE and JACK C. BALL. 1953. The fishes of the upper Guadalupe River, Texas. Tex. J. Sci. 5: 216–244.

HUBBS, CLARK, and KIRK STRAWN, 1957. Relative variability of hybrids between the darters, *Etheostoma spectabile* and *Percina caprodes*. Evolution 9: 1–10.

JORDAN, DAVID STARR, and CHARLES H. GILBERT. 1886. List of fishes collected in Arkansas, Indian Territory and Texas, in September, 1884, with notes and descriptions. Proc. U. S. Nat. Mus. 9: 1–26.

MERRIMAN, DANIEL. 1947. Notes on the midsummer ichthyofauna of a Connecticut beach at different tide levels. Copeia 1947: 281–286.

STRAWN, ROBERT KIRK. 1957. The influence of environment on the meristic counts of the fishes, *Etheostoma grahami* and *E. lepidum*. Unpubl. Ph.D. Dissertation, The Univ. of Texas: 58 pp, 6 tables, 9 figs.

TRAUTMAN, MILTON B. 1957. The fishes of Ohio. Ohio State Univ. Press: xviii + 683 pp.

THE SOUTHWESTERN NATURALIST 3: 17–27 1958 (PRINTED 1959)

SOME PLEISTOCENE AMPHIBIANS AND REPTILES FROM FRIESENHAHN CAVE, TEXAS

JOHN S. MECHAM

Department of Zoology—Entomology, Alabama Polytechnic Institute, Auburn

ABSTRACT. Five anuran amphibians (*Scaphiopus* sp. *couchi* or *hurteri*?, *Eleutherodactylus augusti*, *Bufo cognatus*?, *Rana pipiens*, *Rana* sp. cf. *catesbeiana*), one lizard (*Crotaphytus collaris*), and two snakes (*Pituophis melanoleucus*, *Crotalus atrox*) are identified from late Pleistocene deposits of Friesenhahn Cave, Bexar County, Texas. One fossil toad is described as a new subspecies, *Bufo woodhousei bexarensis*. Most of the fossil species occur in the area today, and no drastic faunal shift or climatic change in more recent times appears to be indicated.

The Friesenhahn Cave is located on Cibolo Creek, 21 miles north of San Antonio in Bexar County, Texas. The fossil fauna of this site was reported on briefly by Hay (1920) on the basis of preliminary investigations. During the summers of 1949 and 1951 the cave was excavated by the Texas Memorial Museum, and a large collection of Pleistocene vertebrates was made. Some parts of this extensive material have been reported on in detail. Kennerly (1956) and Tamsitt (1957) have studied some of the rodents, and Pettus (1956) has reported on the lagomorphs. Milstead (1956) has investigated the fossil turtles. The present report is concerned with the amphibian, snake, and lizard remains.

Detailed descriptions of the deposit have been given by both Milstead and Kennerly, based on notes supplied by Mr. Glenn L. Evans, formerly Associate Director, Texas Memorial Museum. Briefly, it was found that the older fill of the cave consisted of four units designated as zones 1–4. Zones 1–3 formed a stratigraphic sequence, with zone 1 forming the basal layer. Zone 4 consisted of a channel fill containing materials reworked from zone 3, and to some extent from zone 2. Although some vertebrate material was recovered from all zones, zone 3 was by far the most prolific, and except for a few scraps from zones 2 and 4, all lizard, snake, and amphibian remains were found in this zone. On the basis of the associated mammalian fauna the deposit has been referred by Evans (unpublished) to one or more stages of the Wisconsin in the late Pleistocene.

Aside from the zone number, no information was available to the

writer as to the degree of association of the herpetological remains. In some instances, however, such information could be inferred where more than one bone bore the same catalogue number, had been placed in the same container, and agreed closely in color. All of the specimens reported on in the present paper are contained in the collection of the Texas Memorial Museum, University of Texas. Recent osteological material used for comparison is in the writer's collection, the Texas Natural History Collection, and the collection of Dr. Ralph Axtell.

The writer would like to express his appreciation to Dr. John A. Wilson who first suggested the problem and supervised its early stages, and to Dr. W. Frank Blair and Dr. Ralph Axtell for the loan of comparative osteological material. Dr. Walter Auffenberg kindly assisted in the identification of some of the snake material.

SALIENTIA

SCAPHIOPUS species. Two tibio-fibulae (Nos. 933–795 and 933–3644a) are the only only remains of this genus in the collection. In the absence of additional material, it is impossible to draw any definite conclusions as to the species represented, but on the basis of size, it seems possible that the bones belong to either *Scaphiopus couchi* or *Scaphiopus hurteri*. Both elements are comparable in size, and one of the two which is complete except for epiphyses measures 20.3 mm. in length. This is comparable in size to the same bone in a large *hurteri* or *couchi* (one *hurteri* with snout-urostyle length of 55 mm. had a tibio-fibula length of only 18.8 mm.), and is well above the size range of the *hammondi-bombifrons* section of the genus.

ELEUTHERODACTYLUS AUGUSTI Dugès. One left scapula (No. 933–3650) may be referred positively to this genus, and probably to this species. Certain minor differences are evident when compared with two contemporary specimens at hand. These consist of a slightly less pronounced dorsal curvature of the posterior margin of the bone and a somewhat heavier aspect. The specimen is large, and suggests a frog which would fall on the upper size limit of *Eleutherodactylus autusti latrans*, the subspecies which is found in the area today.

BUFO COGNATUS Say (?). This species appears to be represented by one left femur (No. 933–3203) and probably also by one left humerus (No. 933–3640) and one first and one seventh trunk vertebra (No. 933–3649). Recent skeletal material of the genus used for comparison include *Bufo terrestris* (subspecies *terrestris* and *americanus*), *Bufo woodhousei* (subspecies *woodhousei*, *fowleri*, and *velatus*), *Bufo ma-*

rinus (*horribilis*), *Bufo boreas*, *Bufo alvarius*, *Bufo valliceps*, *Bufo punctatus*, *Bufo cognatus*, and *Bufo compactilis*.

Of the fossil elements, the femur is the more diagnostic, and may be identified with a greater degree of certainty. It agrees closely in structural details and size with both *Bufo cognatus* and *Bufo compactilis*. The conformation of the femural crest (fairly high, simple, with a faintly defined secondary ridge diverging on the lower surface) is quite characteristic and similar in these two forms, and both may be distinguished on this basis from the other species examined. Positive identification between these two closely related species is more difficult. An analysis of proportions of the femur involving length, greatest diameter of the distal end, distance from the proximal termination of the crest to the proximal end, and height of the crest were made on series of both species. Broad overlap in all ratios was obtained, with the fossil falling within the range of variation of both forms. Assignment of the fossil to *Bufo cognatus* rests on the fact that the specimen resembles the available material of this form in a slightly more pronounced dorsal deflection of the proximal margin of the crest. This character may not prove to be consistent, and the most that can be said is that the fossil definitely pertains to either *Bufo cognatus* or *Bufo compactilis* (or to the progenitor of these two species), and that a minor (and perhaps not diagnostic) similarity seems to place it with *Bufo cognatus*.

BUFO WOODHOUSEI **bexarensis** subsp. nov.

Type: TM No. 933–3708a. A left femur without the distal epiphysis, and missing approximately seven mm. of the proximal end (Fig. 3).

Paratypes: Two nearly complete femora (Nos. 933–3710a, 933–881), and one fragmentary femur (No. 933–3601).

Referred material: Two nearly complete and two partial ilia (Nos. 933–1695, 933–3650a, 933–3650b, 933–3235), one incomplete tibiofibula (No. 933–3710b), and two partial humeri (Nos. 933–3709a, 933–3709b).

Horizon and type locality: Late Pleistocene, zone 3, Friesenhahn Cave in northern Bexar County, Texas. Paratypic and referred material bear the same data.

Diagnosis: A fossil toad closely allied to, and probably conspecific with, *Bufo woodhousei*, but distinguished from recent races of this species by larger size, and certain features of the limb bones.

Description: The femur is moderately slender, with a low crest on the back face which bifurcates to form a narrow V-shaped elevation, the apex of which is directed distally. The wings of this expansion be-

come subparallel proximally, and attain a maximum width of approximately one half the diameter of the shaft at the proximal end of the crest. The lower wing of the elevation formed by the crest slopes toward the shaft at a steeper angle than the upper one, with the result that the surface of the elevation is tilted slightly toward the ventral side of the bone.

In addition to the type, three other femora are referrable to this form, and have been designated as paratypes. All four specimens agree closely in every detail, and there can be no doubt as to their conspecificity. The proximal end of the bone is incomplete in all four, and in No. 933–3601 the distal end is incomplete as well. No epiphyses are present. The measurements of these bones are given in Table I. Comparison of these bones with the same element in specimens of *Bufo w. woodhousei* and *Bufo marinus* of known body size indicate snout-vent lengths for individuals corresponding to the fossil femora of approximately 123, 117, 117, and 105 mm., respectively.

TABLE 1

Measurements in mm. of four femora of *Bufo woodhousei bezarensis*.

Number of specimen, series 933	3708a	7310a	881	3601
Distal end to proximal termination of crest	32.8	29.6	35.0	...
Estimated total length without epiphyses	38.5	34.7	41.0	38.5
Greatest diameter of distal end	6.3	5.3	6.6	...
Greatest width of crest	2.1	1.7	2.1	2.0
Width of shaft at proximal end of crest	...	3.4	4.1	3.4

Four ilia have been referred to the new form. As these are the only toad ilia in the collection, and as no other femora of *Bufo* aside from those designated as type and paratypes (and the specimen identified as *Bufo cognatus*, a much smaller species) were present, it seems reasonably certain that both ilia and femora pertain to the same species. Three of these ilia, although large, fall below the size range of the type and paratypes, and were derived from animals of approximately 90–100 mm. snout-vent length. The fourth ilium (No. 933–1695, Fig. 1) is much larger, and is almost identical in size with the same bone in a *Bufo marinus* 137 mm. in length. This last ilium measures 37.0 mm. from the anterior margin of the dorsal prominence to the tip of the wing, although the tip of the wing is slightly incomplete.

Maximum depth through the wing is 4.3 mm. Aside from size, the fossil ilia are indistinguishable from those of modern *Bufo w. woodhousei*. The dorsal prominence is well developed, dorsally directed, with slight development of a keel extending up the anterior and posterior surfaces of the prominence.

One right tibo-fibula (No. 933–3710, Fig. 2) has also been referred to the fossil form, in as much as its distinctly bufonid nature and large size leave little doubt that it pertains to the same species. Approximately eight mm. of the distal end is missing, and the bone measures 26.4 mm. from the arterial foramen on the anterior (outer) face to the extremity of the proximal epiphysis. Comparison with contemporary material indicates a total length for the bone of approximately 50 mm., and a snout-vent length for the individual from which it was derived of approximately 160 mm. snout-vent length. Aside from size the bone offers little of diagnostic value. There is no tendency toward development of a ridge along the ventral edge of the shaft as in some contemporary species.

Two bufonid humeri have also been assigned to the fossil subspecies on the basis of size. These are the only toad humeri in the collection aside from a much smaller specimen tentatively assigned to *Bufo cognatus*. The proximal end is missing in both bones. The maximum width of the distal end is 8.3 and 8.7 mm., indicating a toad of approximately 130–140 mm. in total length. There is no evidence of a ridge just proximal to the median epicondyle and only slight development of one just proximal to the lateral epicondyle. These ridges are well developed in many modern forms, including large *Bufo w. woodhousei*.

Comparisons. All of the skeletal elements assigned to the fossil form indicate a toad of large to very large size. Conservatively estimated, this form must have had an average adult size which fell above 100 mm. snout-vent length, and ranged up to 160 mm. On the basis of size alone this Pleistocene toad can be distinguished from all recent North American forms of the genus with the exception of *Bufo marinus* and *Bufo alvarius*. It is readily distinguished from these two forms, however, on the basis of a number of characters. The femural crest is a single sharp ridge in both *alvarius* and *marinus*, without the bifurcation or flattening which forms the narrow V-shaped elevation in *bexarensis*, and is much lower in *marinus*. The dorsal prominence of the ilium is lower in both recent forms, particularly *marinus*, and is more laterally directed. There is a tendency toward development of a ridge along the ventral edge of the shaft of the tibio-fibula in *Bufo alvarius*, and the humerus of this species has distinctively flaring ridges proximal to the lateral and medial epicondyles. Differences of

equal magnitude (in addition to smaller size) distinguish other forms used for comparison with the exception of *Bufo woodhousei*. Apparently, the fossil form falls closest to this species, particularly the western subspecies *Bufo w. woodhousei*, the largest subspecies of the *woodhousei* complex and the race which occurs in the region today. Relationship is strongly indicated by the ilium, which agrees closely in the two forms in the height of the dorsal prominence and general

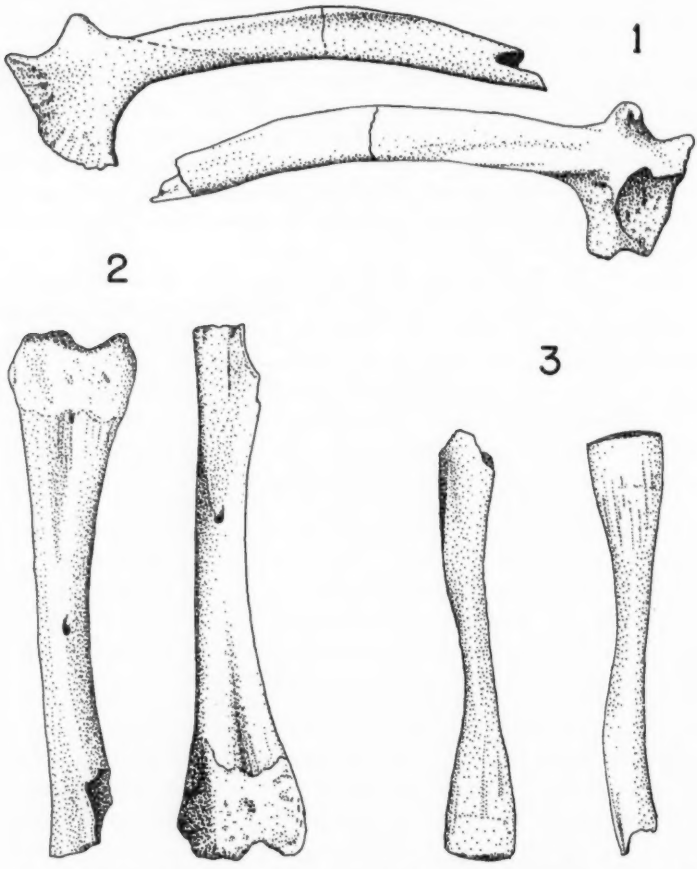


Fig. 1–3. Bones of *Bufo woodhousei bexarensis*. 1. Left ilium, No. 933-1695, inner face above, outer face below. 2. Right tibio-fibula, No. 933-3710b, outer face on left, inner face on right. 3. Left femur, type, No. 933-3708a, ventral face on left, dorsal face on right. Refer to the text for exact measurements.

shape of the wing. The femur is also quite similar. In *Bufo w. woodhousei* the femural crest is low, and in most specimens (as in *bexarensis*) shows a distinct bifurcation or flattening, giving rise to a secondary ridge which slopes gradually toward the shaft, forming, with the primary ridge or crest, a narrow V-shaped elevation or plateau which is tilted slightly toward the lower side of the bone. In other forms examined (with the exception of some *terrestris* and other subspecies of *woodhousei*) the secondary ridge is absent or only faintly indicated and the femural crest forms a single sharp ridge, or the secondary ridge diverges more sharply from the primary ridge and slopes more rapidly toward the shaft, either failing to form a distinct elevation, or forming one which is tilted steeply toward the lower side of the bone. The fossil tibio-fibula, although not as diagnostic in nature, agrees well with *woodhousei* in the absence of any indication of a ridge on the ventral edge of the shaft and a slight compression of the tibial element distal to the arterial foramen.

The most obvious difference exhibited by the fossil form as compared with recent *Bufo w. woodhousei* is that of size. The subspecies *woodhousei* reaches a fairly large size, and probably approaches *bexarensis* as closely in this respect as any other North American toad except for *alvarius* and *marinus*. Nevertheless, it falls definitely below the size of the fossil form. Wright and Wright (1949) give the adult size of *Bufo w. woodhousei* as 56–99 mm. for males and 58.5–118 mm. for females. It is a rare individual that measures as much as 118 mm., however, and the modal range is doubtless much below this. Sizes of individuals of *bexarensis* as calculated from the relative size of the fossil bones all fall above 104 mm. snout-vent length with the exception of three ilia, and even these indicate toads of 90–100 mm., a size which falls near the upper limits of most *woodhousei* populations. Five of the fossil bones (a femur, an ilium, a tibio-fibula, and two humeri) fall well above the recorded upper size limit for recent *woodhousei*. Differences also distinguish the limb elements. These differences seem most marked as compared with the largest *Bufo w. woodhousei*, suggesting the possibility that they may, at least in part, be the result of comparison of different age groups of two forms which differ in total size. In all femora of *bexarensis* the V-shaped elevation formed by the femural crest is very narrow, and reaches a greatest width of approximately one half or slightly more of the width of the shaft at the proximal end of the crest. In large specimens of *Bufo w. woodhousei* there is a tendency for the crest to become expanded, and in the largest specimens examined the crest attained a width equal to the diameter of the shaft. The tibio-fibula of *bexarensis* also appears to be

somewhat more slender than the same element in the larger *woodhousei*. In the two largest specimens of *woodhousei* available for comparison (females with snout-vent lengths of 103 and 104 mm.) the ratio of minimum width of the shaft to distance from the arterial foramen on the anterior surface to the proximal end of the bone is .184 and .188 respectively, but is only .159 for the fossil bone. Smaller specimens of *woodhousei* are close to the fossil form in this ratio. Another difference seems apparent in the humerus. As already mentioned, the two fossil humeri show no development of a median epicondylar ridge or crest and only slight development of a lateral one. These ridges are well developed in most of the larger species examined, particularly in the larger individuals. They are present in *Bufo w. woodhousei*, and all of the larger *woodhousei* skeletons available are readily distinguishable from the fossil material on this basis. In some of the smaller specimens these ridges are reduced, and the bone is not so distinctive.

Bufo w. woodhousei has been identified from the Pleistocene of Kansas by Tihen (1954) who states that his material is indistinguishable from large specimens of this subspecies. The deposit from which these specimens were collected has been correlated with the Sangamon interglacial, and therefore, is probably older in origin than the Friesenhahn deposit. In view of the conflict in age, it seem unlikely that this subspecific identification is valid unless the Friesenhahn material was derived from a geographically distinct population. The fact that the Kansas remains are large may be indicative of a tendency toward the larger size which is exhibited by *bexarensis*.

RANA PIPIENS Schreber. Number 933–3640 is definitely referable to this species. The specimen consists of the left tibio-fibula, the distal two-thirds of the right tibio-fibula, both humeri, both coracoids, the right scapula, the right radio-ulna, and the distal end of the left femur. There is little doubt that all of these bones pertain to the same individual. All bear the same catalogue number, left and right elements agree perfectly, and all of the bones are of a size relative to one another as would be expected in the same individual. Contemporary skeletal material used for comparison included *Rana catesbeiana*, *Rana grylio*, *Rana heckscheri*, *Rana clamitans*, *Rana septentrionalis*, *Rana areolata* (subspecies *areolata* and *capito*), *Rana palustris*, and *Rana pipiens*.

The fossil material agrees in all details with *Rana pipiens*, and is distinguishable from the other forms on the basis of a combination of characters, most particularly the more slender tibio-fibula and the absence of a median epicondylar ridge with poor development of a lateral epicondylar ridge on the distal end of the humerus. The com-

plete tibio-fibula (minus epiphyses) measures 50.4 mm. in length, with transverse diameters of 2.8 mm. at the center of the shaft, and 5.1 mm. at the distal end. The right humerus (again minus epiphysis) measures 22.4 mm. in length. Size of these bones indicates a frog of approximately 100 mm. snout-vent length.

RANA species. One right tibiale (No. 933–3597) seems to be referable to this genus, but is too large to belong to the preceding form. The bone is 26.7 mm. in length, with approximately 6 mm. of the distal end missing. Comparison with *Rana catesbeiana* indicates a frog with a snout-vent length of roughly 155 mm., but specific identification is impossible without additional material.

LACERTILIA

CROTAPHYTUS COLLARIS Say. One left mandible (No. 933–2442) consisting of most of the dentary, but lacking the coronoid, angular, surangular, and articular portions, can be definitely identified with *Crotaphytus*. Comparative material of both *Crotaphytus collaris* and *Crotaphytus reticulatus* has been available for comparison, but the fossil material does not permit distinction between the two. On the basis of present distribution the mandible is referred tentatively to *Cotaphytus collaris*.

SERPENTES

PITUOPHIS MELANOLEUCUS Daudin. The specific designation is used here in the inclusive sense as proposed by Smith and Kennedy (1951) in which *catenifer* and *melanoleucus* are combined. There are some 84 vertebrae in the collection which are assigned to this species. Dr. Walter Auffenburg, who has kindly aided in the identification of this material, states (written communication) that the vertebrae definitely belong to *Pituophis* and seem to approach eastern *melanoleucus* most closely in the relative height of the neural spine. However, in the absence of complete series of large skeletons of western subspecies, he felt that no subspecific allocation could be made.

CROTALUS ATROX Baird and Girard. Hay (1920) tentatively listed this species from the Friesenhahn deposit. Material available to him consisted of about 50 vertebrae (most if not all belonging to one specimen), a few ribs, one fang, and a left ramus minus the dentary.

There are some 38 crotalid vertebrae in the present collection, all of which, with the exception of seven specimens from zone 4, were collected in zone 3. Most of this material shows no measurable differences from *Crotalus atrox*, and therefore is assigned to this species.

Some of the vertebrae are unusually large, and suggest a snake over six feet in length.

In addition to the vertebrae, there is one maxillary bone complete with fang (No. 933–2443) in the collection. This specimen agrees in all details with *Crotalus atrox*.

DISCUSSION

All of the fossil amphibians and reptiles discussed in this paper which are represented by diagnostic material appear to be assignable to existing species. The general association of genera and species (*Scaphiopus*, *Eleutherodactylus augusti*, *Bufo cognatus* or *compactilis*, *Bufo woodhousei*, *Rana pipiens*, *Crotaphytus collaris*, *Pituophis melanoleucus*, *Crotalus atrox*) is one which is found today throughout the Balconian biotic province (see Blair, 1950), the biogeographic region in which the Friesenhahn Cave is located. Particularly characteristic of the Balconian is *Eleutherodactylus augusti*, a saxicolous form which is adapted to the rocky limestone hills of the Edwards Plateau. This material, therefore, does not indicate any faunal shift of great magnitude in more recent times. This general picture is largely supported by published reports on the small mammals of the deposit. *Perognathus hispidus* has been reported by Kennerly (1956), *Peromyscus leucopus*, *P. maniculatus*, and *P. nasutus* by Tamsitt (1957), and *Lepus californicus*, *Sylvilagus floridanus*, and *S. auduboni* by Pettus (1956). Of these only *Peromyscus nasutus* and *Sylvilagus auduboni* are not found in this part of Texas today.

Tamsitt (loc. cit.) has pointed out that the presence of *Peromyscus nasutus*, a form presently limited to the mountainous regions of the southwest, is probably the result of a climatic shift during the Wisconsin which enabled the extension of this form to areas from which it has subsequently disappeared with post-Wisconsin climatic change toward aridity. This would seem to imply that the climate in central Texas was more moist at the time of formation of the Friesenhahn deposit than is the case today. Similarly Milstead (1956), who has reported the turtle *Terrepene canaliculata* from this deposit, suggests that in as much as *canaliculata* may be directly ancestral to modern *Terrepene carolina*, an eastern form which reaches its western limits of distribution in Texas in the Texan biotic province, the presence of *canaliculata* in the Friesenhahn may be indicative of a more moist climate. Other remains so-far described neither confirm nor absolutely refute this hypothesis. The presence of *Sylvilagus auduboni*, recorded in the Friesenhahn but found today to the south and west of this locality, could be interpreted as evidence for a more arid climate.

Other remains of small mammals, reptiles, and amphibians so-far recorded, excluding the possibility of subspecific shifts in the wide ranging forms, seem consistent with climatic conditions similar to those of today.

An interesting feature of some of the fossil material is a tendency toward a size larger than that of the existing species in central Texas. Pettus has demonstrated this tendency in *Sylvilagus floridanus*, Kennerly has pointed out a similar condition in the *Perognathus*, and the data of Tamsitt indicate that the fossil *Peromyscus leucopus* was larger than the surviving subspecies of the area. The same phenomenon appears to occur in some of the poikilotherms. *Bufo woodhousei bexarensis* is distinguishable from modern *Bufo woodhousei* largely on the basis of greater size, and Milstead has pointed out that *Terrepene canaliculata*, which may well be the ancestor of modern *Terrepene carolina*, can be consistently distinguished from the latter only by its larger size. Much of the other herpetological material discussed in this paper, although falling within the size limits of the contemporary species, was derived from specimens of large size, and is not inconsistent with the hypothesis of a trend toward increased size. Evidence at hand, however, still seems inadequate to establish whether there is actually a general trend toward larger size in the material as a whole, or that this is an unrelated phenomenon occurring in just a few forms. If such a trend does exist, it seems probable that poikilotherms as well as homoiotherms are involved.

LITERATURE CITED

BLAIR, W. FRANK. 1950. The biotic provinces of Texas. Tex. J. Sci. 2 (1): 93–117.

HAY, OLIVER P. 1920. Descriptions of some Pleistocene vertebrates found in the United States. No. 2328. Pro. U. S. Nat. Mus. 58: 83–146.

KENNERLY, THOMAS E., JR. 1956. Comparisons between fossil and recent species of the genus *Peromyscus*. Tex. J. Sci. 8: 74–86.

MILSTEAD, WILLIAM W. 1956. Fossil turtles of the Friesenhahn Cave, Texas, with the description of a new species of *Testudo*. Copeia (3): 162–171.

PETTUS, DAVID. 1956. Fossil rabbits (Lagomorpha) of the Friesenhahn Cave deposit, Texas. S. W. Nat. 1 (3): 109–115.

SMITH, HOBART M., and J. P. KENNEDY. 1951. *Pituophis melanoleucus ruthveni* in eastern Texas and its bearing on the status of *P. catenifer*. Herpetologica 7 (3): 93–96.

TAMSITT, J. R. 1957. *Peromyscus* from the late Pleistocene of Texas. Tex. J. Sci. 9 (3): 355–363.

TIHEN, J. A. 1954. A Kansas Pleistocene herpetofauna. Copeia (3): 217–221.

WRIGHT, A. H., and A. A. WRIGHT. 1949. Handbook of frogs and toads of the United States and Canada. Ed. 3. Ithaca, xii + 640 p.

THE SOUTHWESTERN NATURALIST 3: 28–54 1958(PRINTED 1959)

OBSERVATIONS ON AMPHIBIANS AND REPTILES OF THE BIG BEND REGION OF TEXAS

SHERMAN A. MINTON, JR.

Indiana University Medical Center, Indianapolis, Indiana[1]

ABSTRACT. Distribution and derivation of the Big Bend herpetofauna is briefly discussed. The general picture is one of a xeric grassland fauna at lower elevations and rock crevice species at higher. Most of the species are characteristic of (1) the arid basins of the southwestern U. S. and northwestern Mexico (2) the Chihuahuan Desert and northern Sierra Madre Orientale. A few species appear to be relicts associated with montane forest. Almost one fourth of the species are endemic, show locally differentiated populations, or are isolated to some extent.

Based on personal collecting and literature records, 69 species are known from the area. Notes on variation, habits, and habitat are given for many.

DISTRIBUTION AND DERIVATION OF THE HERPETOFAUNA

The interesting composition of the herpetofauna in the Big Bend Region of southwestern Texas has been known for well over a half century. Increasing numbers of collectors have visited the area as improved transportation has gradually made it more accessible. Qualitatively speaking, the fauna is now tolerably well known, and most of the species are adequately represented in museum collections. There is still need for distributional, ecological, and life history observations as well as for further collecting in the lesser known sections of this rugged and highly diversified country. An annotated list of reptiles and amphibians known from Big Bend National Park and vicinity has been published by Schmidt and Smith (1944). Additional records from Trans-Pecos Texas are found in the papers of Murray (1939), Jameson and Flury (1949), Brown (1950), and Milstead and coworkers (1950).

My observations on the reptiles and amphibians of the Big Bend Region were made from February 16, 1955 to August 8, 1955. During this time I lived with my family on the Rosillos Ranch at the north

[1] The author is now on the staff of the Basic Medical Science Institute at Karachi, Pakistan, and did not have the opportunity to read proofs of his paper. (Editor's note.)

base of the Rosillos Mountains. Field work was carried out almost continuously save for about a week in May during which time I was collecting in another section of the state. The area within which nearly all collecting was done is bounded to the north by U. S. Highway 90, to the south by the Rio Grande, to the east by State Highway 227 and the east boundary of the National Park, and the west by State Highway 118 and the west boundary of the National Park. Some 350 reptiles and amphibians were preserved and a number collected alive for zoos and interested individuals. No attempt was made to obtain large series of the more plentiful species.

Sperry and Warnock (1941) have discussed the physiography, climate, and flora of the Big Bend Region. Other faunal papers treating ecological conditions in some detail are those of Borrell and Bryant (1943) on mammals and Tinkham (1948) on Orthoptera. Lewis (1950) has discussed the ecology of reptiles and amphibians in the Tularosa Basin and Organ Mountains of New Mexico, an area comparable to Big Bend in many respects.

The Big Bend Region lies near the eastern margin of the Chihuahuan Desert. It is a land of semiarid plains interrupted by prominent mountain belts. Altitudes range from 1873 feet near Boquillas on the Rio Grande to 7834 feet on Emory Peak in the Chisos Mountains. According to National Park Service data, rainfall in the Chisos Basin from 1950 to 1955 varied from 9.02 inches to 18.01 inches annually, while at Persimmon Gap in the desert flats at the north edge of the National Park annual rainfall varied from 4.24 to 8.28 inches. Most precipitation is during the summer with lesser amounts during late spring, autumn, and early winter. Mean January temperatures in the Chisos Basin range from 50.0° to 56.5° F., and mean July temperatures from 72.9° to 76.5° F. For Boquillas, mean January temperature estimated from incomplete data is 59° F. and mean July temperature 87.5° F. Sudden marked drops in temperature accompany February and March wind storms. As in all arid lands, there is considerable diurnal variation in temperature.

Most of the Big Bend Region lies in the Lower Sonoran life zone, but appreciable portions of the high prairie and the higher mountain ranges extend into the Upper Sonoran. Certain elements of the Transition zone appear on the highest peaks of the Chisos Mountains. As determined by distribution of amphibians and reptiles, I recognize the following five habitat zones:

The Marathon-Alpine Grassland (Upper Sonoran) consists of plains and grassy hills mostly at 4000 to 5000 feet elevation. The soil is rocky, but cliffs and other massive rock formations are not con-

spicuous. Dominant plants are grama and chino grasses (*Bouteloua* sp.) intermixed with three awn grass (*Aristida*) and muhly grass (*Muhlenbergia*). Juniper (*Juniperus monosperma*) and cholla (*Opuntia imbricata*) are conspicuous larger plants. Permanent water is represented by some large springs and numerous artificial impoundments; temporary, shallow ponds are formed in many places during the rainy season. Grazing is the chief form of land use.

The Mountain Zone (Upper Sonoran to Transition) is chiefly confined to areas above 5500 feet. It is best developed and known in the Chisos, but exists with certain modifications in the Del Norte and Glass Mountains. Rock slides, cliffs, and other massive rock formations are a very conspicuous feature. Characteristic trees include several species of oaks and junipers, Mexican pinon (*Pinus cembroides*), and Texas madrone (*Arbutus texana*). The giant agave (*Agave scabrosa*) is a typical plant. Local stands of pondorosa pine, Douglas fir, and Arizona cypress represent Transition zone flora. There are a few small meadows of needle grass (*Stipa* sp.). Permanent water is supplied by small springs.

The Desert Foothills and Mesas (Lower Sonoran) comprise most of the mountainous areas below 5000 feet. Their facies are usually rocky and rugged and may be largely stratified sedimentary rocks as in the Santiago and Dead Horse ranges or largely igneous boulders as in the Rosillos and Corazones Peaks. Dominant plants are lechuguilla (*Agave lechuguilla*), yuccas (*Yucca* sp.), and sotol (*Dasylirion leiophyllum*). Trees such as hackberry, oaks, Mexican walnut (*Juglans rupestris*), and Mexican buckeye (*Ungnadia speciosa*) occur in canyons with springs, otherwise forest cover is lacking.

The Desert Flats (Lower Sonoran) is a zone best developed below 3000 feet. The soil is chiefly adobe clay, but some areas are predominantly coarse gravel. Massive rock outcrops are mostly confined to canyons and draws. The dominant plant is creosote bush (*Larrea*), frequently associated with catsclaw (*Acacia greggi*), cacti (*Opuntia, Echinocereus*), yucca, and ocotillo (*Fouquieria splendens*). Along the larger draws are mesquite (*Prosopis*), Texas persimmon (*Diospyros texana*) and desert willow (*Chilopsis*). Larger trees are absent save for an occasional willow or cottonwood at the few springs or water holes.

The Rio Grande Lowland (Lower Sonoran) consists of the river and its flood plain and the lower parts of larger streams such as Terlingua and Tornillo Creeks. Its width on the U. S. side varies from a few yards to somewhat over a mile. The soil is adobe clay in most places, but there are some areas of almost pure sand. Willows, cottonwood, cane (*Phragmites*), mesquite, and screwbean (*Strombocarpa*)

are characteristic plants. Parts of the area are under cultivation. There are a few sloughs and occasional natural or artificial ponds. The great canyons of the Rio Grande probably represent a distinct habitat zone in themselves. They have been little investigated zoologically and are not treated in this paper.

The general picture of reptile and amphibian distribution is one of a xeric grassland fauna at lower elevations and a group of cliff or rock crevice species at higher elevations. Only a few species are true desert forms, but the abundance of some, e.g. *Cnemidophorus tigris marmoratus*, suggests that they are on their way to dominance. A few species such as *Gerrhonotus liocephalus infernalis* and *Ancistrodon contortrix pictigaster* are evidently associated with remnants of upland forest.

We found no species truly ubiquitous in the Big Bend. Those encountered in the greatest variety of habitats were the large, active snakes, *Masticophis flagellum*, *M. taeniatus*, and *Pituophis;* the whiptail lizard, *Cnemidophorus sacki;* and, rather surprisingly, the small gecko, *Coleonyx*. Nearly as widely distributed were *Crotaphytus collaris*, *Holbrookia texana*, *Bufo punctatus*, *Phrynosoma modestum*, and *Crotalus atrox*. Most of the species, however, seem restricted to a single biotope.

The Big Bend herpetofauna has clearly been recruited from several sources. According to present distribution of the species (excluding subspecies), I have recognized the influence of six faunae. Eight species (Table 1) have transcontinental or nearly transcontinental ranges. Their origins are uncertain, but many appear to be southwestern. The greatest number of species (Table 2) show a distribution pattern centering in the arid basins of the southwestern United States and northwestern Mexico including a good portion of the west coast. Most of them also occur in Baja California. In general, this group avoids major mountain ranges. A number of the species range extensively into the Great Plains region of the central United States. About half the species in this group are primarily desert animals, while most of the others are grassland-desert forms.

Nine species (Table 3) are typical of the Great Plains and Mexico east of the Sierra Madre Occidental. They show a limited tendency to range westward into more arid regions. Four species (*Trionyx spinifera*, *Natrix erythrogaster*, *Elaphe obsoleta*, and *Ancistrodon contortrix*) are characteristic of the southeastern United States and in Big Bend approach the extreme western limit of their range. *Syrrhopus marnocki* evidently is characteristic of the Edwards Plateau of Texas,

and the range of *Eumeces brevilineatus* also seems to center about this region.

The more characteristic reptiles and amphibians of Big Bend include 16 species (Table 4) with distribution centering about the Chihuahuan Desert or the northern Sierra Madre Orientale and extending to west Texas, southern New Mexico, and extreme southeastern Arizona. Eleven of these species are montane or rock crevice animals, and the others desert or grassland-desert inhabitants.

Four species in this group (*Sceloporus merriami*, *Lampropeltis alterna*, and *Tantilla cucullata*) are considered Big Bend endemics, having their known ranges confined to southern Trans-Pecos Texas and adjoining Coahuila and Chihuahua. An additional 7 species (Table 5) have recognized subspecies largely confined to this region. Additional evidence of endemism is shown by 7 species (Table 6) whose Big Bend populations are isolated and/or slightly differentiated. Thus almost one-fourth of the species are endemic, show locally differentiated populations, or are to some degree isolated from their nearest neighbors.

TABLE 1

Big Bend species having an essentially transcontinental range. *Diadophis punctatus* (including *amabilis* and *regalis*) and *Pituophis melanoleucus* + *catenifer* are here considered monotypic species, although the validity of such an arrangement has not been conclusively established.

Ambystoma tigrinum	Masticophis flagellum
Bufo woodhousei	Lampropeltis getulus
Rana pipiens	Diadophis punctatus
Pseudemys scripta	Pituophis melanoleucus

TABLE 2

Big Bend species showing a pattern of distribution centering in the arid basins of the southwestern United States and northwestern Mexico. Those designated with an asterisk range extensively into the Great Plains regions as well.

Scaphiopus hammondi*	Bufo punctatus*
Scaphiopus couchi	Gastrophryne olivacea*
Bufo debilis*	Hyla arenicolor
Coleonyx variegatus	Urosaurus ornatus
Crotaphytus collaris*	Sceloporus magister
Crotaphytus wislizeni	Cnemidophorus sacki*
Holbrookia maculata*	Cnemidophorus tigris
Uta stansburina	

Leptotyphlops humilis
Thamnophis cyrtopsis
Salvadora hexalepis
Arizona elegans*
Rhinocheilus lecontei*
Sonora semiannulata
Hypsiglena torquata*
Crotalus atrox*
Crotalus molossus
Crotalus scutulatus
Crotalus viridis*

TABLE 3

Big Bend species with ranges centering in the Great Plains region of the United States and Mexico east of the Sierra Madre Occidental.

Kinosternon flavescens
Terrapene ornata
Phrynosoma cornutum
Sceloporus undulatus
Eumeces obsoletus

Leptotyphlops dulcis
Thamnophis marcianus
Heterodon nasicus
Elaphe guttata

TABLE 4

Big Bend species with distribution centering about the Chihuahuan Desert, northern Sierra Madre Oriental and mountains of west Texas, southern New Mexico, and extreme southeastern Arizona.

Bufo compactilis
Holbrookia texana
Phrynosoma modestum
Sceloporus merriami
Sceloporus poinsetti
Cnemidophorus perplexus
Cnemidophorus tessellatus?
Gerrhonotus liocephalus

Salvadora grahamiae
Masticophis taeniatus
Elaphe subocularis
Lampropeltis alterna
Ficimia cana
Tantilla atriceps?
Tantilla cucullata
Trimorphodon vilkinsoni
Crotalus lepidus

TABLE 5

Subspecies with ranges largely restricted to southern Trans-Pecos Texas and adjoining Mexico.

Pseudemys scripta gaigeae
Urosaurus ornatus schmidti
Sceloporus merriami annulatus
Cnemidophorus sacki semifasciatus
Elaphe obsoleta bairdi
Sonora semiannulata blanchardi
Ancistrodon contortrix pictigaster

TABLE 6

Species whose Big Bend population is isolated and/or slightly differentiated.

Syrrhophus marnocki
Hyla arenicolor

Diadophis punctatus
Masticophis flagellum
Pituophis melanoleucus
Salvadora grahamiae
Hypsiglena torquata

ANNOTATED LIST OF SPECIES

In this section are listed all species definitely known from the Big Bend region. I have omitted several for which records are doubtful or indefinite.

For each species I have listed collections made, selected published records, and general remarks on distribution. Material collected has been deposited in the following institutions: The Chicago Natural History Museum (CNHM), University of Michigan Museum of Zoology (UMMZ), Illinois Natural History Survey, Urbana (INHS), and the personal collection of the author (SAM). Specimens designated LPZ were collected by the Lincoln Park Zoo field party or sent alive to the zoo by me. The abbreviation, DOR, is used to designate specimens found dead on the road and not preserved. Most of the localities listed are to be found on the U. S. Geological Survey Quadrangle maps; a few more recent ones on National Park maps. Elevations were estimated with the aid of these maps as well as by reference to bench marks and other local markers.

In scientific nomenclature I have, in general, followed the Check List of North American Amphibians and Reptiles, Sixth Edition (Schmidt, 1953). Departures therefrom are explained under "Notes." Under this heading I have also included selected scale counts, measurements, and notes on color of live specimens. Personal observations on the food, behavior, and reproduction of the various animals are listed. I have not usually attempted to summarize the observations of others on these topics.

SALAMANDERS (CAUDATA)

AMBYSTOMA TIGRINUM MAVORTIUM Baird. BARRED TIGER SALAMANDER. 4½ mi. ssw. Marathon (SAM), 12 mi. w. Marathon (UMMZ). Also Alpine and 4 mi. n. Alpine (Brown). Apparently restricted to the prairie.

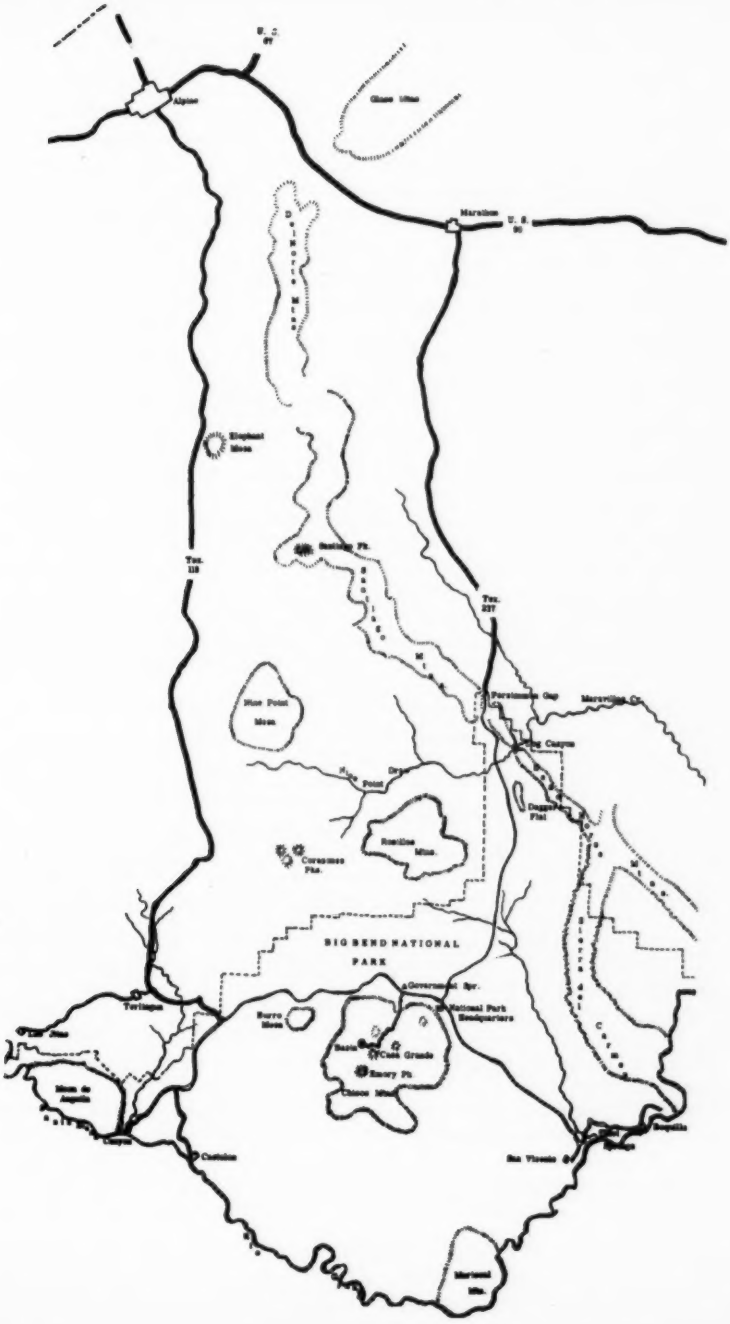
An adult male (body length 127 mm., total length 249 mm.) was collected about 11 p.m. June 30 in a shallow, grassy pond. There had been a moderate shower shortly after sunset, and the air temperature was 66° F. A fully transformed juvenile (body length 79 mm.) was secured in a similar site the night of July 21. In neither case were other salamanders seen in the ponds.

FROGS AND TOADS (SALIENTIA)

SCAPHIOPUS COUCHI Baird. SONORAN SPADEFOOT TOAD. North base Rosillos Mtns. (UMMZ–5), 10½ mi. n. Persimmon Gap (CNHM), 8 mi. s. Persim-

---

Sketch Map of the Big Bend Region showing principal roads and localities mentioned in the text.


Marathon
Glass Mtns
Chisos Mtns
Elephant Mtn
Tex 118
Tex 227
Persimmon Gap
Marathon Cr.
Blue Front Mtn
Dugout Flat
Castolon Flat
Hamilton Mtn
BIG BEND NATIONAL PARK
Terlingua
Panther Mtn
Basin
Chisos Mts
Emory Pk
Dominguez Spr.
National Park Headquarters
Rio Grande
Boquillas
Castolon
Santa Elena Canyon
Mariscal Mtn

mon Gap (CNHM), 15 mi. e. Alpine (CNHM 2), 4½ mi. ssw. Marathon (CNHM). Also Alpine and Terlingua (Brown). Widely distributed in prairie and desert flats.

Males from breeding choruses were often almost uniform light green; females yellowish green with strong dark reticulation.

Sonoran spadefoots were first noted the night of May 4 during a heavy downpour. They were moving toward a grassy field bordering Nine Point Draw. The following two nights there were moderately heavy choruses from flooded sections of this field, the spadefoots being concentrated in pools free from the sweep of current. They were subsequently heard following every moderate to heavy shower but were not heard when the field was inundated after a heavy rain on the headquarters of the draw without local precipitation. Immature spadefoots were often seen hopping about at dusk, though there had been no rain.

SCAPHIOPUS HAMMONDI HAMMONDI Baird. HAMMOND'S SPADEFOOT TOAD. 3 mi. w. Marathon (SAM 3), 5 mi. n. Alpine (CNHM 2). Previously recorded in area only from Alpine (Brown). Apparently restricted to the prairie.

Specimens were almost putty color when collected at night. By day they were light greyish brown with a little dark pigmentation around the warts of the back and hind legs.

This species was not noted until July 19 after heavy rains in the Marathon area. A large chorus located July 21 was in a water filled excavation associated with *Bufo debilis insidior* and *B. compactilis speciosus*. The spadefoots lay sprawled on the surface near the center of the pool where the water was 3 to 5 feet deep and dived promptly when alarmed. No females were taken, nor was amplexus observed. About dusk August 3 I saw an immature specimen on the highway and an adult that took refuge in a mammal burrow. Twice after handling these animals I experienced irritation of my nose and eyes resembling the symptoms of moderately severe hay fever. I believe it quite likely that the spadefoots' skin secretion was responsible for my discomfort, although other causes could not be excluded.

BUFO COMPACTILIS SPECIOSUS Girard. TEXAS TOAD. 3 mi. w. Marathon (CNHM 2), between Persimmon Gap and Twin Mills (INHS 3), 8 mi. nw. Hot Springs (INHS), n. base Rosillos Mtns. (UMMZ), Boquillas (LPZ). These records represent a slight extension of the range shown by H. M. Smith (1947). All are for semiarid situations at low altitudes.

A juvenile was taken February 26 at the edge of a stock pond shortly after dark. Males were seen calling from the bank of a water filled excavation near Marathon the night of July 21.

BUFO DEBILIS INSIDIOR Girard. WESTERN GREEN TOAD. 8 mi. s. Persimmon Gap (INHS 5), 4½ mi. ssw. Marathon (SAM 2), 12 mi. w. Marathon (UMMZ 2), n. base Rosillos Mtns. (CNHM 2). Occurrence widespread in the short grass prairie and desert flats.

One was taken March 18 hopping about at dusk. No others were seen until after the first heavy rain April 29. On June 30, July 19, and July 21, they were noted in choruses associated with *Scaphiopus couchi*, *S. hammondi*, and *Bufo c. speciosus* in muddy, temporary ponds. Pairs in amplexus were observed at these times.

BUFO PUNCTATUS Baird and Girard. RED-SPOTTED TOAD. Tornillo Flats 11 mi. n. National Park Headquarters (INHS 7), 10 mi. nw. Hot Springs (INHS 6), 5 mi. n. Persimmon Gap (UMMZ 3), 25 mi. s. Alpine (CNHM 2), 2 mi. n. National Park Headquarters (UMMZ 2), n. base Rosillos Mtns. (CNHM 2). Numerous sight records indicate abundance throughout river bottom, desert flats, and

desert foothills. Uncommon in the prairie and no records for higher and rockier mountain areas.

In life, these toads are dull brown to putty color with pale red to orange dorsal warts. In about 10 per cent, the warts are distinctly margined with black, and there is black ventral speckling.

Red-spotted toads living in crevices under our house emerged regularly on warm, still evenings and were occasionally active by day. They were first noted March 18. They seem to protect themselves from heat, drought, and enemies by retreating into crevices instead of burrowing as do spadefoots. Rain brings out red-spotted toads in numbers. Choruses were heard between May 9 and July 21 from pools in the beds of creeks and from isolated desert rain pools. In no case were they associated with other breeding amphibians. Newly transformed young were found under rubbish at Hot Springs on June 2.

BUFO WOODHOUSEI AUSTRALIS Shannon and Lowe. SOUTHWESTERN GARDEN TOAD. Hot Springs (LPZ). Also Boquillas, Serna Ranch on the east side of the Chisos, and mouth of Santa Elena Canyon. May be largely restricted to lowland along the Rio Grande.

Apparently uncommon. Heard calling the night of April 25.

HYLA ARENICOLOR Cope. CANYON TREEFROG. Boot Spring, Chisos Mtns. (SAM, UMMZ 1 + several tadpoles), Cattail Falls, Chisos (LPZ). Also Fern Canyon near Alpine (Wright and Wright 1949, p. 292).

Living individuals were grayish to tawny with very restricted dark dorsal markings.

At Boot Spring (7000 ft.) these frogs were found in a wooded canyon containing permanent pools of water. They were usually seen clinging to boulders near the pools but were occasionally found in slide rock at a considerable distance from water. They were in chorus during early July. Tadpoles 35–40 mm. in length were plentiful July 25 and 26.

SYRRHOPHUS MARNOCKI Cope. CLIFF FROG. Not collected. The published records are for springs and canyons above 5000 feet in the Chisos Mountains (Schmidt and Smith as *S. gaigeae*). The prolonged drought in this region may have accounted in part for our failure to find this frog.

RANA PIPIENS BERLANDIERI Baird. RIO GRANDE LEOPARD FROG. Base of Rosillos Mtns. (CNHM 2, UMMZ 2), Hot Springs (UMMZ 3, SAM several tadpoles), 4 mi. ssw. Marathon (CNHM), 3 mi. w. Marathon (CNHM), 15 mi. s. Alpine (CNHM). Plentiful at several points along the Rio Grande and observed in ponds and tanks throughout most of the area. Found about springs in the Rosillos but not in the Chisos above 4000 feet.

Following Schmidt and Smith, I have assigned these leopard frogs to the subspecies *berlandieri*. Brown's tentative assignment of Trans-Pecos leopard frogs to *brachycephala* is not, in my opinion, sustained by material from the Big Bend. In my material, the males have large and distinct vocal vesicles, the tympanum lacks a distinct light center in preserved specimens but may show such in life, and the snout spot is absent or tiny. The dorsal spots are variable in size and shape, and light borders are absent or very faint.

In the Big Bend region, leopard frogs apparently breed throughout most of the year. Eggs, large tadpoles, and small tadpoles were observed February 16 at the mouth of Tornillo Creek. When this site was revisited April 25 just before the rains, the mats of algae swarmed with young frogs, in the shallow water were shoals of tadpoles and several egg masses, and a few males were calling. On May 10 after two

hard rains had driven the river out of its banks, very few leopard frogs of any size could be found. Such sudden, violent fluctuations in stream level and current evidently take a heavy toll of young frogs and tadpoles.

In a stock pond at the north base of the Rosillos Mountains, leopard frog egg masses were noted February 20. New egg masses appeared until March 15, at which time the earlier masses were hatching; however males continued to call through April and were heard occasionally during June and July. An egg mass and many tadpoles, some nearing transformation, were found April 6 at Goat Spring in the Rosillos. Calling males and egg masses were noted near Alpine on July 21.

GASTROPHRYNE OLIVACEA Hallowell. WESTERN NARROW-MOUTHED TOAD. North base Rosillos Mtns. (CNHM 4), 10 mi. nw. Hot Springs (INHS), 4½ mi. ssw. Marathon (UMMZ). Evidently the first definite report from Big Bend. Records show rather extensive range in grassland at low altitudes.

Evidence for uniting *Gastrophryne olivacea* and *G. carolinensis* seems inconclusive, hence the use of the binomial.

Calls of the narrow-mouthed toad were first heard May 1 in the flooded section of a grassy field and were heard intermittently during the following two months, beginning at twilight. Calling individuals were usually concealed among partly submerged grass stems. They were associated with *Scaphiopus couchi* and *Bufo d. insidior*. The only non-breeding individual was taken on the road at night during rain.

TURTLES (CHELONIA)

KINOSTERNON FLAVESCENS FLAVESCENS Agassiz. YELLOW MUD TURTLE. 3 mi. s. Persimmon Gap (UMMZ), 8 mi. s. Persimmon Gap (UMMZ), 9 mi. s. Marathon (SAM), Dagger Flat (UMMZ 2). Sight records and reports indicate the species is widely distributed at low altitudes.

These turtles inhabit shallow, quiet bodies of water that often are very muddy, contain little aquatic vegetation, and may be dry two to three months each year. During rainy weather, two were found on roads at considerable distances from any known body of water. I have seen them feed on carrion and aquatic invertebrates such as snails, belostomatids, and larval Odonata.

TERRAPENE ORNATA ORNATA Agassiz. ORNATE BOX TURTLE. 6 mi. e. Alpine (UMMZ), 9 mi. ne. Alpine (UMMZ), Marathon (DOR). In the Big Bend apparently restricted to short grass prairie.

The specimens were taken in the open following rains. They differ from specimens collected in Illinois and Indiana only in their slightly greater size.

PSEUDEMYS SCRIPTA GAIGEAE Hartweg. BIG BEND TERRAPIN. Hot Springs (UMMZ), Boquillas. Seemingly favorable habitats exist only in a few sloughs of the Rio Grande and tanks located within a mile or so of the river. The sudden and marked fluctuations in river level must have an adverse effect on this turtle.

TRIONYX SPINIFERA EMORYI Agassiz. TEXAS SOFTSHELL. Hot Springs (UMMZ, INHS). Sight records for Boquillas Canyon, Castolon, and the mouth of Santa Elena Canyon indicate general distribution along the Rio Grande.

Softshells were frequently seen basking on sand bars. The sighting of several February 16 indicates hibernation probably does not take place in this area. A typical *Trionyx* egg was found April 26 on a sand bar a few feet from the water. Efforts to find the remainder of the clutch or the female were unsuccessful.

LIZARDS (SAURIA)

COLEONYX VARIEGATUS BREVIS Stejneger. TEXAS BANDED GECKO. Rosillos Mountains area (UMMZ 3, CNHM 2), 2 mi. sw. Study Butte (UMMZ), Dog Canyon, Santiago Mtns. (INHS), Government Spring (SAM), Corazones Peaks (CNHM), Hot Springs (SAM), 12 mi. nw. Hot Springs (INHS), 15 mi. s. Alpine (CNHM). As widely distributed as any lizard in the Big Bend. Observed from the banks of the Rio Grande to about 6000 ft. on Casa Grande. Most plentiful in moderately rocky desert.

In February and March, geckos were rather plentiful under boards, rubbish, and thin slabs of rock. They were occasionally seen active by day in rock crevices and trash piles. After May 4, the only ones encountered were under large, deeply embedded rocks or were on roads or trails at night. They seemed most active on still nights just after rain. If cornered, these lizards often depress their head, elevate their tail, and wave it about. Many emit faint squeaks when handled. No gravid females or very young juveniles were seen.

CROTAPHYTUS COLLARIS BAILEYI Stejneger. WESTERN COLLARED LIZARD, MOUNTAIN BOOMER. Lower slopes Rosillos Mtns. (CNHM, UMMZ), Santiago Mtns. near Persimmon Gap (CNHM), Dog Canyon (CNHM), 10 mi. e. Alpine (UMMZ), 12 mi. s. Alpine (UMMZ). Widely distributed but not found in the Chisos above the lower limit of the oak-pinon forest.

Interorbital scales are in two complete series in 4 of 6 specimens, and two pairs of scales in the series are fused in the others. Most specimens showed prominent, narrow, transverse orange bars on the neck and body.

These lizards were often seen along roads and were easily recognized by their size and habit of running bipedially. They were most numerous in rocky, open desert. Juveniles were collected February 28 and March 6 in burrows under rocks, but no adults were positively identified until late April. A female collected July 13 contained large eggs. The stomachs of two specimens contained cicadas, beetles, and grasshoppers.

CROTAPHYTUS WISLIZENI WISLIZENI Baird & Girard. LEOPARD LIZARD. Base of Rosillos Mtns. (CNHM, UMMZ, SAM), 12 mi. se. National Park Headquarters (DOR). Also Boquillas and San Vicente (Brown). Largely confined to low desert.

Near the Rosillos, leopard lizards were found in sandy washes and open flats, often crouched under prickly pear or catclaw. The lizards could be approached to within a yard or so before disappearing into thickets or mammal burrows. I saw one struggling with an adult gray whiptail *(Cnemidophorus tigris marmoratus)* that it subdued and swallowed head first. Another leopard lizard had eaten a half grown gray whiptail.

HOLBROOKIA TEXANA SCITULA Peters. SOUTHWESTERN EARLESS LIZARD. Rosillos Mtns. area (UMMZ 3, CNHM 2), 5 mi. n. Persimmon Gap (CNHM 2), 15 mi. s. Alpine (CNHM), 18 mi. s. Alpine (UMMZ), National Park Headquarters (UMMZ), Santiago Mtns. near Persimmon Gap (CNHM) Burro Mesa (CNHM). Occurs from the banks of the Rio Grande to elevations of about 5200 ft. in the Rosillos but does not extend into the oak-pinon forest of the Chisos.

Active adult males are among the most colorful of lizards. The general dorsal hue is light gray becoming lavender with fine spotting and reticulation of orange anteriorly. Posteriorly the body is bright grass green to yellow. A spot of blue surrounds

the black lateral bars. Females are brownish to gray, often with a rosy tinge along the flanks.

This is one of the most plentiful and frequently observed reptiles in desert and semidesert habitats. It evidently has wide temperature tolerance. It was the only reptile active after the severe "norther" of March 26–27, yet it is the only lizard other than the gray whiptail regularly abroad during the midday heat of June and July. I do not believe any lizard in the area can equal it in speed, and a thoroughly alarmed individual may run 50 yards or more. It may then take refuge under very superficial cover such as cardboard or sheet metal. As the lizard runs, the tail is often curled over the back showing the black and white underside. Sometimes one will run a short distance and perch on a rock or other object. It then may elevate its tail and wave it about. I have seen these lizards asleep on the highway or incompletely buried in loose soil.

The brilliantly colored males were very excitable during late April and early May. They inflated their bodies, engaged in vigorous bobbing, and behaved aggressively toward other males. On May 6, I saw a pair of these lizards in copulation. The first hatchling was found June 29.

HOLBROOKIA MACULATA APPROXIMANS Baird. SPECKLED EARLESS LIZARD. 10 mi. e. Alpine (CNHM 3), 15 mi. s. Alpine (CNHM 2), 11 mi. s. Alpine (SAM 2), 9 mi. ne. Alpine (UMMZ), Marathon (UMMZ). Apparently confined to the prairie.

Males have yellowish throats, dusky mottled chins, and a tinge of blue about the lateral bars. Females have the throat, neck, and lips tinged with yellow and the flanks suffused with vermilion.

These lizards were usually found about patches of almost bare ground with sparse grass and xerophytes. They are strictly terrestrial and less active than *H. texana*. Mammal burrows are their usual refuges. One of 3 females collected July 13 contained large eggs.

PHRYNOSOMA CORNUTUM Harlan. TEXAS HORNED TOAD. 9 mi. ne. Alpine (UMMZ), west base Elephant Mesa (CNHM), 2 mi. w. Marathon (DOR). Mostly confined to the short grass prairie. Occurrence elsewhere including the Chisos Basin (Schmidt and Smith) may indicate existence of small colonies on islands of grassland.

PHRYNOSOMA MODESTUM Girard. RAT-TAILED HORNED TOAD. 15 mi. n. Persimmon Gap (UMMZ 2), base of Rosillos Mtns. (UMMZ, SAM), Green Gulch (Chisos) (UMMZ), National Park Headquarters (UMMZ), Marathon (CNHM), 15 mi. s. Alpine (CNHM), 25 mi. s. Alpine (UMMZ). Occurs in most of the more arid parts of Big Bend to altitudes of slightly more than 5000 feet.

There is much variation in color. Specimens from the Chisos are pinkish, while some from the Rosillos are flecked heavily with bluish gray. Those from the limey soils near Marathon are flour white, while those from the Woodward Ranch south of Alpine closely match the dark reddish volcanic soil as do *Holbrookia texana* and *H. maculata* in this area.

Although fairly plentiful about the base of the Rosillos, this species was not seen until April 18. It is most active during mid morning and late in the afternoon. It is often found in extremely arid and barren situations, its colors making it difficult to see against the soil. Earl Steele reported finding a pair of these lizards in copulation on the highway on May 13. A hatchling 21 mm. in body length was collected July 3 at the base of the Rosillos.

SCELOPORUS MAGISTER BIMACULOSUS Phelan & Brattstrom. TWIN-

SPOTTED SPINY LIZARD. Base of the Rosillos Mtns. (UMMZ 3, CNHM, SAM), Hot Springs (CNHM). Occurrence seems limited to arid situations below 4000 feet.

These specimens agree with the description of the subspecies by Phelan and Brattstrom (1955). The following notes were made of the color of an adult male in life: "Dorsum tinged with blue, sides flecked with bright yellow, throat and belly patches brilliant blue green."

These big lizards were found in rocky situations and about old buildings. Adults are terrestrial. Although not particularly fast, they are exceedingly wary and seem never to wander far from dense thickets, pack rat nests, rock crevices, and other refuges. I saw one about 10 p.m. apparently asleep with its head and shoulders buried in loose soil. On being touched, it ran into a nearby kangeroo rat burrow. The young are more arboreal. One was seen on a tree trunk and took refuge in an abandoned bird nest; another was taken in a thatch roof.

This species was first observed March 3. Spring observations indicated three distinct size groups, one of about 50 mm. body length and clearly young of the previous summer, one of 70–75 mm. apparently individuals a year older and still immature, and finally adults of 95 mm. or more. A hatchling with body length of 33 mm. was taken July 19.

SCELOPORUS POINSETTI Baird and Girard. CLIFF LIZARD. Casa Grande (UMMZ 2, SAM), Chisos Basin (LPZ), base of Emory Peak (UMMZ), Santiago Mtns. (SAM), 15 mi. s. Alpine (CNHM). Literature records indicate general distribution in mountainous areas from 2900 to at least 6800 feet.

Most of the specimens were dark brown to dark gray with indistinct dull yellow crossbands. The specimen from the Santiagos, however, was light tan above with some scales flecked with orange and blue.

These large lizards frequent cliffs and other massive rock formations where they may be seen basking or climbing on vertical surfaces. They are occasionally observed on the ground or in trees. Their habitat and that of *Sceloporus magister* seem mutually exclusive for the most part. *S. poinsetti* was first observed March 30 in the Chisos. Young of hatchling size were first noted July 16–18.

SCELOPORUS UNDULATUS CONSOBRINUS. Baird & Girard. SOUTHERN PRAIRIE LIZARD, TREE LIZARD. Rosillos Mtns. (UMMZ 2, SAM) Chisos Mtns., Laguna Meadow (SAM), Kibbee Spring, Casa Grande (CNHM), 10 mi. e. Alpine (CNHM, SAM). Occurrence general in the prairie and in the mountains to at least 6500 feet; elsewhere spotty avoiding more arid situations.

Colonies of this lizard in the Rosillos are located in canyons that contain springs and support a few trees. In the Chisos, the species frequents the pinon and juniper forest. The lizards are often seen on logs or the bases of trees and climb to avoid capture. On the prairie near Alpine, however, they are ground lizards associated with *Cnemidophorus* and *Holbrookia maculata.*

Females containing large eggs were collected in the Rosillos on April 26, near Alpine July 13, and in the Chisos June 1 and July 16. One from the latter locality laid 7 eggs July 19. Hatchlings were observed near Alpine on August 4.

SCELOPORUS MERRIAMI MERRIAMI Stejneger. MERRIAM'S CANYON LIZARD. Dog Canyon, Santiago Mtns. (UMMZ 3, INHS 7), Persimmon Gap (CNHM 3), Hot Springs (SAM 2). Occurs along the Rio Grande and northward in the Dead Horse and Santiago Mountains.

SCELOPORUS MERRIAMI ANNULATUS Smith. BIG BEND CANYON LIZARD. Rosillos Mtns. (UMMZ 4, CNHM 4), Corazones Peaks (CNHM 2, SAM), Chisos Basin (UMMZ 2), 1 mi. sw. Terlingua (UMMZ 2). Evidently confined to

the somewhat isolated mountains of the southern Big Bend. Although *merriami* tends to occur at lower altitudes than *annulatus*, the two are not strictly segregated on this basis. I collected *merriami* from about 1900 to 3700 feet and *annulatus* from about 3300 to 5500 feet.

The subspecies *annulatus* was easily differentiated using the criteria of Smith (1946, pp. 188–190). In addition to these differences in color and pattern, the two subspecies can usually be differentiated in the field by their ground color. *S. m. merriami* is pallid, often appearing quite ashen, with dark dorsal spotting greatly reduced; while *annulatus* is darker tending to be reddish brown and well spotted dorsally, often tending to show a dark nuchal collar. A few specimens intermediate between the two subspecies in color, pattern, and scalation were collected on a rather isolated boulder cone at the northeast base of the Rosillos and in a small canyon near Terlingua.

No constant differences were noted in the habits of the two subspecies. Both are common on bare rocks. They climb vertical surfaces with ease and sometimes cling to the underside of boulders. They enter crevices when alarmed but are not particularly cautious and often reappear within a few seconds. One bit a finger poked into its retreat. Specimens were collected early in March when weather was quite cool. It is doubtful if hiberation takes place save perhaps at higher altitudes. During the hot months, these lizards are most active for a two hour period before darkness and for a similar period about two hours after sunrise.

Behavior similar to the courtship of *Sceloporus undulatus* was noticed in the Rosillos April 21, but no mating was witnessed. Collections made in early spring show many young lizards with body lengths of 28–34 mm. About mid-July, hatchlings with body lengths of about 20 mm. begin to appear. The remainder of the population consists almost wholly of sexually mature lizards with body lengths of 40 mm. or more.

UROSAURUS ORNATUS SCHMIDTI Mittleman. BIG BEND UTA. Rosillos Mtns. (CNHM 5, UMMZ), Dog Canyon (UMMZ 2), Chisos Basin (UMMZ), Cattail Falls (INHS), 1 mi. w. Alpine (SAM), 15 mi. s. Alpine (SAM). Occurrence apparently general in mountainous sections from about 2700 to at least 6000 feet.

The entire venter of males is turquoise blue with little evidence of separate belly patches; females have bluish white bellies and pale orange throats.

This lizard is frequently associated with *Sceloporus merriami* on cliffs and boulders. At higher levels in the Chisos and in some of the canyons, it may also be found on trees. It is moderately secretive and an inveterate climber.

I identified no females of this species until May 6, at which date two from the Rosillos contained large eggs. Males had been observed since March 6 and were numerous early in April. By mid-June, Rosillos females were mostly spent, but one containing eggs was collected in the Chisos June 16. Very small young were seen in the Rosillos July 31.

A uta living on our porch was seen feeding on insects attracted to the light.

UTA STANSBURNIANA STEJNEGERI Schmidt. GROUND UTA, BLUE-SPOTTED LIZARD. Base of Rosillos Mtns. (UMMZ 2, CNHM 2), 5 mi. n. Persimmon Gap (CNHM), 15 mi. n. Persimmon Gap (UMMZ), 2 mi. nw. Boquillas (CNHM), Hot Springs (CNHM). Plentiful in desert flats and foothills and along the Rio Grande. Not observed above about 4000 feet.

The dorsum of both sexes is spangled with sky blue, more conspicuously so in males. The dorsal stripes are pale yellow to white. The entire underside of males is

bluish shading to indigo on the throat; females have the blue confined to the chest, chin, and throat. Both sexes have pale orange spots on the chin and throat.

Ground utas were found in colonies often located about old buildings or trash dumps. They live under boards and rubbish or in mammal burrows and do not climb. During the cool weather of February and early March, the ground uta was the most frequently observed reptile in the Rosillos area, being most active about midday. Later in the season it was most active in the early morning and just before sunset.

On March 13 and 14, males were seen in pursuit of females, but no mating was recorded. The first hatchling was taken June 18, and very small individuals were plentiful thereafter.

EUMECES BREVILINEATUS Cope. SHORT-LINED SKINK. Goat Spring, Rosillos Mtns. (CNHM 3). Brown records this species from Alpine and from several localities in the Chisos to 7000 feet altitude. It seems restricted to islands of mesic forest in the Big Bend.

The few short-lined skinks I saw in the Big Bend were in comparatively moist situations, crawling in ground litter or concealed under rocks.

EUMECES OBSOLETUS Baird & Girard. GREAT PLAINS SKINK. Chisos Basin (SAM 2, UMMZ, INHS), Cattail Falls (CNHM). Recorded from the Rio Grande valley at Hot Springs and Boquillas; rare or absent in the desert.

These big skinks were moderately plentiful in the more humid parts of the Chisos. None were seen until after the first rains in early May. They were seen near rock outcrops or clumps of lechuguilla. Two were found in coition under a large rock slab May 2. A young one with body length of 37 mm. was collected July 15.

CNEMIDOPHORUS TIGRIS MARMORATUS Baird and Girard. GRAY WHIPTAIL. Base of Rosillos Mtns. (UMMZ 4, CNHM 2), Hot Springs (UMMZ 4), 20 mi. s. Marathon (CNHM 2), 5 mi. n. Persimmon Gap (UMMZ), 2 mi. nw. Boquillas (CNHM), Dog Canyon (UMMZ), 1 mi. sw. Terlingua (SAM). Very plentiful on desert flats and sandy areas along Rio Grande. Less abundant in the foothills and rare or absent in the prairie or at elevations above 5000 feet.

Schmidt and Smith, Brown, and others list this species as *C. tessellatus*. Some specimens are almost uniform drab gray, some show light vertical bars on the trunk. The ventral color is pale yellow shading to peach on the chest and throat. Black spotting of the throat is usually sparse or lacking, ventral spotting sparse to moderate. Young differ from adults only in reduced ventral pigment. Femoral pores (combined count) number 42–48.

Despite the abundance of these lizards near our house, none were seen until March 13 when the temperature at midday reached 85° to 90° F. They are active in the intense heat of mid summer, tending to appear later in the morning and disappear earlier in the evening than the other lizards associated with them. Their homes are in mammal burrows at the base of cactus, creosote bush, or other shrubs. Sometimes several whiptails will inhabit the same system of burrows. They seem to have recognizable home ranges and behave aggressively toward other lizards that trespass upon them including individuals of their own species.

A pair of these lizards was observed in copulation July 6. A hatchling was collected August 1, and others had probably been seen during the last week of July.

A large gray whiptail was seen dragging a small *Holbrookia texana* that was dead when released and doubtless would have been eaten. Others were seen feeding upon such large, active insects as robber flies, grasshoppers, and dragon flies.

CNEMIDOPHORUS TESSELLATUS GRAHAMI Baird & Girard. CHECK-

ERED WHIPTAIL. Tres Cuevas Mtn. between Terlingua and Las Jitas (CNHM), Santa Elena Canyon (Texas Cooperative Wildlife Coll. 5). Also Chisos, San Vicente, Burro Mesa (Brown). Occurrence spotty and evidently restricted to arid mountains, mesas, and canyons.

All specimens are females. I have never seen a male of this species from any part of the range. W. G. Degenhardt who collected the Santa Elena Canyon specimens writes, "Common along the river . . . it is difficult to collect as it is extremely wary and takes cover in the reeds."

CNEMIDOPHORUS SACKI SEMIFASCIATUS Cope. BIG BEND STRIPED WHIPTAIL. Rosillos Mtns. (CNHM 6, UMMZ), National Park Headquarters (UMMZ), Green Gulch, Chisos (UMMZ), Laguna Meadow, Chisos (SAM), Chisos Basin (CNHM, LPZ), Corazones Peaks (CNHM), Santiago Mtns. (SAM). A lizard of the mountains and desert foothills, absent at low altitudes except where lava flows or canyons provide suitable rocky habitat. Observed from 2000 to 6800 feet.

The name *octolineatus* has been applied to this form by most earlier workers, some treating it as a species, others as a subspecies. I find it readily identifiable with *semifasciatus* as redefined by Burger (1950). Characteristics observed in my material are: Blackish fields between the dorsal stripes broken up posteriorly by expansion of light spots in them; belly white in both sexes; marked rusty suffusion of rump and proximal portion of tail; frenocular separate from loreal in 7 specimens, in contact unilaterally in 3, and bilaterally in 2; femoral pores 35–45 (mean 38.25); maximum body length 98 mm.

Very young individuals have body lengths of 36–38 mm. The spots between the stripes are discrete and do not break up the zones of ground color, and the tail is bluish gray.

This lizard is usually observed in rocky situations with sparse vegetation. It rarely climbs on cliffs or other steep rock surfaces but seeks shelter under rocks or in crevices. It is less active than other members of its genus, and its actions suggest those of a skink rather than a whiptail.

A juvenile 44 mm. in body length was collected in the Rosillos March 9, but large adults did not appear in numbers until late April. Females containing large eggs were collected in June and early July. The first individuals of hatchling size were noted July 31.

It is my impression that this lizard feeds upon smaller, less active prey than does the gray whiptail. Striped whiptails often root about in ground litter, overturning sticks and rocks with their nose and lapping up the small insects thus uncovered.

CNEMIDOPHORUS SACKI SSP. PRAIRIE STRIPED WHIPTAIL. 10 mi. e. Alpine (CNHM 3, SAM 2), 5½ mi. s. Alpine (UMMZ 2), 18 mi. s. Alpine (CNHM 2). The records are for short grass prairie and grassy hills.

This population is clearly distinct from the population in the southern Big Bend. Some individuals resemble *C. sacki gularis* while others are close to *C. s. exsanguis*. The most conservative solution at present seems to be to treat this population as intergrade between these two subspecies. Features observed in my material are: Snuff brown to olive fields between dorsal stripes; light spots small, discrete, do not break up fields between stripes; no rusty suffusion of rump and tail; males with blue bellies and pink throats; frenocular in contact with loreal bilaterally in 5 specimens, unilaterally in 2, separate in 1, head badly damaged in 1; femoral pores 30–39 (mean 34.4); maximum body length 80.5 mm. Intergrades between this form and *semifasciatus* were not observed.

The specimens were obtained in low, slightly damp, grassy sites and on hills in

the sparse juniper-cholla-sotol association. There seems to be no tendency to frequent rocky sites. In general, this form seems more active and alert than *semigasciatus*. A female collected July 1 contained eggs nearly ready for deposition.

CNEMIDOPHORUS PERPLEXUS Baird & Girard. LITTLE STRIPED WHIPTAIL, BLUETAILED RACERUNNER. Dagger Flat (CNHM 3), 10 mi. e. Alpine (UMMZ 2), Lone Mtn. near National Park Headquarters (SAM), 8 mi. n. National Park Headquarters (UMMZ), Persimmon Gap (CNHM), Marathon (CNHM). Numerous records for the prairie, desert flats, and desert foothills; none for the higher mountains or Rio Grande lowland.

For the use of the name *perplexus* instead of *inornatus* see Milstead (1957). All specimens have bright blue tails and a pattern of 7 bright yellow lines on a uniform dark background. Bellies and faces of males are bright sky blue. Postantebrachials are not enlarged in 3 and slightly enlarged in 6; femoral pores 26–32 (mean 29.1); maximum body length 60 mm.

Near Marathon and Alpine, this whiptail occurs in flat, open places almost devoid of vegetation and seems to be the dominant lizard in such sites. At Dagger Flats, it is common in an area of grass and mesquite but was not noted in the surrounding creosote bush-yucca association. In the desert foothills, it was collected in lechugilla flats associated with *C. s. semifasciatus* and *C. t. marmoratus* and was not plentiful. No hatchlings of *C. perplexus* were seen; one 30 mm. in body length was collected on March 4.

GERRHONOTUS LIOCEPHALUS INFERNALIS Baird. TEXAS ALLIGATOR LIZARD. Chisos Basin (UMMZ 2), Laguna Meadow (SAM 2), Emory Peak (INHS), Boot Spring (UMMZ). Most records for the Chisos above the level of the pinon forest and to 7500 feet on Mount Emory. Also recorded from Terlingua (Brown).

I obtained the species under logs in needle grass meadows and in the open or under rocks in the oak-pinon-juniper forest. The slow, sinuous movements of this animal are very different from the scurrying of the desert lizards. The tail is prehensile. Large ones bite powerfully, and the short teeth produce painful scratches. The stomach of one specimen contained a scorpion and several large beetles. A very young alligator lizard, 45 mm. body length, was collected July 17.

SNAKES (SERPENTES)

LEPTOTYPHLOPS DULCIS DISSECTA Cope. NEW MEXICO BLIND SNAKE. Castolon (SAM). Chisos Basin (Schmidt & Smith), Oak Creek Canyon (Klauber, 1940).

The head of my specimen is so badly crushed the supraoculars and supralabials cannot be examined. By the method of Klauber *(op. cit.)*, the actual count of dorsal scales is 224. Assuming 5 to 10 scales were destroyed with the damaged head, this count fits *dulcis* rather than *humilis*. Dorsal scale counts of two CNHM specimens from the Chisos Basin are 229 and 230. All 3 specimens have 10 scale rows around the tail.

The Castolon specimen was unearthed by road grading machinery in a sandy place near the Rio Grande March 8. Sotero Morin who collected it said another snake of the same kind was found nearby but escaped.

LEPTOTYPHLOPS HUMILIS SEGREGUS Klauber. TRANS-PECOS BLIND SNAKE. Burro Mesa (Schmidt & Smith), Chalk Draw (Klauber, 1940), 15 mi. sw.

Marathon *(ibid.)*, 65 mi. s. Alpine *(ibid.)*. All localities in the desert flats and foothills.

The specimen from Burro Mesa has 271 dorsal scales and 10 scale rows around the tail.

Virtually nothing is known of the ecology and habits of the two species of *Leptotyphlops* in the Big Bend. There is a slight suggestion from the locality records that *L. humilis* occurs in more arid situations than *L. dulcis*.

DIADOPHIS REGALIS BLANCHARDI Schmidt and Smith. THIMBLE SNAKE. Dog Canyon, Santiago Mtns. (SAM), east base Rosillos Mtns. (CNHM). Also Chisos Basin and Alpine (Brown), Lost Mine Peak, Chisos (Degenhardt, pers. comm.). May be widespread but occurrence evidently spotty; 2700 to 6850 feet.

Both specimens are females. One has 232 ventrals, 57 subcaudals, total length 510 mm., tail 82 mm.; the other has 226 ventrals, 54 subcaudals, total length 495 mm., tail 72 mm. Neither has a neck ring. In life, one was light greenish gray above; the other medium bluish gray approximating the color of many eastern *D. punctatus*. Undersurfaces of both bright chrome yellow shading to vermilion on the tail; diffuse black speckling of entire undersurface including chin and labials.

Both were collected in the open about two hours after sunrise in desert terrain with sparse, xeric vegetation. Actual sites of collection were slightly damp, one was about 200 yards from a small spring. When approached, these snakes flattened their heads against the ground and elevated their tightly curled tails showing the bright red underside. With continued annoyance, one rolled belly up with the body tightly kinked and remained so for perhaps a minute.

One collected June 8 laid 5 eggs June 14. They had an average length of 30 mm. and diameter of 9 mm. Several had the slightly curved form of eastern Diadophis eggs. All failed to hatch.

HETERODON NASICUS KENNERLYI Kennicott. MEXICAN HOGNOSE SNAKE. None collected. Two in CNHM from 1 and 7 miles east of Alpine. Residents of the Alpine-Marathon prairie know this snake but say it is rare. Both specimens are males; ventrals 133 in each; one has 41 subcaudals, tail of other incomplete; body blotches 30 and 29.

MASTICOPHIS FLAGELLUM TESTACEUS Say. RED RACER. Base of Rosillos Mtns. (CNHM 2, LPZ 2, SAM), 11 mi. n. National Park Headquarters (INHS), 15 mi. n. National Park Headquarters (UMMZ), 5 mi. e. National Park Headquarters (UMMZ), 2 mi. s. Persimmon Gap (UMMZ), Bone Spring, near Persimmon Gap (SAM), Marathon (CNHM), Hot Springs (LPZ). Generally distributed to at least 6500 ft. in the Chisos. Most plentiful in desert flats and foothills.

All adults collected or observed were at least somewhat reddish above, varying from pale pinkish tan to bright vermilion; ventral color dusky salmon to pale peach with dusky mottling on chin and throat. The few juveniles seen were straw color above with wide, indistinct dark crossbands and yellow bellies. Maslin (1953) restricted *testaceus* to pinkish populations in Colorado, reviving the name *flavigularis* for the wide ranging coachwhip of the southern Great Plains. Presence of pinkish snakes in the Big Bend casts doubt upon the desirability of this arrangement. Ventrals in my specimens range from 189 to 194 (mean 191.3), lower than reported by Maslin for the Colorado population but probably not significantly so. The largest specimen (male) measured 67 inches and lacked the tip of the tail.

Red racers are diurnal and were most frequently seen during the morning or after showers. They are chiefly terrestrial but occasionally climb into low shrubs. One large one was taken in shallow water at the edge of the Rio Grande. None were seen

prior to March 13, and most adults were seen during late April and May. As racers go, their disposition is mild. George Sholly took a pair in copulation on April 30.

Unidentified small mammal remains were found in digestive tracts of three. I saw one large racer enter a burrow at the base of a mesquite. A few seconds later, a wood rat ran from another burrow with the snake in pursuit. One racer was seen eating carrion (lizard?) on the highway.

MASTICOPHIS TAENIATUS ORNATUS Baird & Girard. CENTRAL TEXAS WHIPSNAKE, BLACKSNAKE. Lower slopes Rosillos Mtns. (CNHM, UMMZ, SAM), Lone Mtn. near National Park Headquarters (SAM), Chisos Basin (LPZ), Dog Canyon (UMMZ). Characteristic of rocky desert foothills but wide ranging to at least 6000 feet.

In pattern and color, these snakes conform closely to the description by Wright and Wright (1957, pp. 456–58). Ventrals 202–213; subcaudals in 5 males are 146, 149 (2), 151, and 153, in 3 females 141, 142, and 149.

Nearly all these snakes were taken during March and April in rocky or brushy situations; more were observed than captured. I saw three with the foreparts of their bodies protruding from rocky crevices into which they drew when alarmed. Others were found in brush piles, under rubbish, and in low shrubs. They are trim looking snakes but nervous and bad tempered. Local residents told me they had seen them feed upon lizards.

A female collected May 6 deposited 5 eggs June 1. Two hatched August 2. The hatchlings measured 349 and 355 mm. They were dark brown to black with a wide whitish stripe on scale rows 3, 4, and 5, and two narrow, indistinct pale stripes below this. The belly color was yellow to pale orange.

SALVADORA GRAHAMIAE Baird & Girard. MOUNTAIN PATCHNOSED SNAKE. Oak Spring, Chisos (UMMZ), Corazones Peaks (CNHM), 1 mi. w. National Park Headquarters (UMMZ), 3 mi. n. National Park Headquarters (CNHM), 5 mi. w. Government Spring (SAM), 25 mi. s. Alpine (UMMZ). Largely restricted to the foothills and mesas from about 3300 to 5500 feet.

The ground color is grayish yellow, richer in hue between the paravertebral stripes. The belly is peach. One individual shows a very faint pair of lateral dark stripes. Ventrals in 4 males number 181–189 (mean 185), subcaudals 100–110 (mean 106.5); ventrals in 5 females 188–194 (mean 190.6), subcaudals 109, 110, and 112; upper labials normally 8, 9 in one; lower labials 9 in 4 specimens, 10 or 10–9 in 5.

The mountain patchnosed snake was usually seen on mild, sunny mornings. It was first observed February 26. In the brush, it is quick and often escapes, but on the highway it tends to "freeze" at the approach of a car and is readily caught. One was taken as it was swallowing a ground snake (*Sonora*).

A female collected April 1 deposited 6 eggs May 29. Three of these hatched August 27–28. The hatchlings measured 263, 264, and 267 mm. and were virtually identical with adults in color and pattern.

SALVADORA HEXALEPIS DESERTICOLA Schmidt. BIG BEND PATCHNOSED SNAKE. East base Rosillos Mtns. (UMMZ), Tornillo Flat 11 mi. n. National Park Headquarters (SAM). Also Chisos foothills and Mesa de Anguila (Schmidt & Smith). Evidently replaces *S. grahamiae* on the desert flats, however both species occur in the foothills and mesas.

One found basking March 6, the other found April 13 in a sandy wash with the anterior quarter of its body buried; both specimens were taken in open places almost

devoid of vegetation. The remains of a third were found in the nest of a redtailed hawk.

ELAPHE GUTTATA EMORYI Baird & Girard. GREAT PLAINS RAT SNAKE. Not collected. Recorded in the Big Bend only at San Vicente in the Rio Grande valley (Brown).

ELAPHE OBSOLETA BAIRDI Yarrow. BAIRD'S RAT SNAKE. Not collected. Published records are for the Chisos above 5500 feet and for Ranger Canyon near Alpine (Wright & Wright, 1957).

Borrell and Bryant (1942) obtained two of these snakes while trapping mammals at Laguna Meadow in the needle grass-pinon-agave habitat.

ELAPHE SUBOCULARIS Brown. TRANS-PECOS RAT SNAKE. Government Spring (UMMZ), SAM), 24 mi. s. Alpine (CNHM), 20 mi. s. Marathon (LPZ). Spring (UMMZ, SAM), 24 mi. s. Alpine (CNHM), 20 mi. s. Marathon (LPZ). ducing to 23 or 21 posteriorly; ventrals 264, 262, 269; subcaudals 70, 70, 76; body and tail blotches 21 + 7, 23 + 10, 21 + 9.

Near Government Spring on the north side of the Chisos where this snake appears to be rather plentiful, the habitat is gently rolling, rocky desert with lechuguilla, sotol, and cacti as dominant plants. The elevation is 4500 to 5000 feet. South of Alpine and Marathon, this snake was taken in rocky, sparse grassland with some juniper, yucca, cholla, and sotol. All my specimens were collected on the highway at night. Three were found about an hour after sunset, a fourth at 11:30. This latter snake had recently swallowed two mice (*Peromyscus* sp.).

PITUOPHIS CATENIFER SAYI Schlegel. BULL SNAKE. North base Rosillos Mtns. (UMMZ, CNHM), Chisos Basin (LPZ), 3 mi. s. Persimmon Gap (UMMZ), Marathon (UMMZ), Widely distributed to at least 6000 feet but nowhere particularly plentiful.

These snakes are decidedly more pallid than specimens from the eastern part of the range. The blotches are reddish to tan on a pale yellow ground color. There is little or no black pigment on the top of the head and labials. The colors suggest those of *P. c. affinis* rather than *sayi*, but the rostral is high and narrow as in *sayi*. Ventral, subcaudal, and blotch counts for Big Bend specimens fall within the normal limits of variation for both *affinis* and *sayi* using Klauber's (1947) figures.

Bull snakes were first noted March 31 and were subsequently observed in a variety of habitats, particularly in grassland and the less arid sections of the desert flats. All live ones were observed by day, but one DOR clearly was killed between sunset and 10 p.m.

ARIZONA ELEGANS ELEGANS Kennicott. TEXAS GLOSSY SNAKE. Not collected. Reported by Klauber (1946) from between Marathon and Alpine and 3 mi. w. of Government Spring.

LAMPROPELTIS ALTERNA Brown. DAVIS MOUNTAIN KINGSNAKE. Not collected. The only record is for Casa Grande in the Chisos about 6000 feet (Murray).

Fragmentary data on this rare snake indicate it is a rock crevice inhabiting animal and largely nocturnal. It has been reported to feed upon lizards.

LAMPROPLETIS GETULUS SPLENDIDA Baird & Girard. SONORA KINGSNAKE. Government Spring (UMMZ), Alpine (Brown). Uncommon, perhaps spotty in distribution.

This specimen and another photographed by Steele were on the highway after dark. My specimen is an adult female with 215 ventrals and 48 subcaudals. There are 53 light crossbands on the body, 13 on the tail.

RHINOCHEILUS LECONTEI TESSELLATUS Garman. TEXAS LONGNOSED

SNAKE. West base Elephant Mesa (CNHM), 8 mi. e. National Park Headquarters (UMMZ), ne. base Rosillos Mtns. (CNHM). Also reported from Government Spring, Glenn Springs, Persimmon Gap. Evidently restricted to low and moderate elevations.

These specimens differ from specimens collected in central Texas in that the red areas between the black blotches are paler, the rostral less sharply upturned, and the tip of the snout tan rather than reddish. Ventrals in females 192 and 194, subcaudals 46 and 47, black body blotches 26. Ventrals in male 196, subcaudals 55, blotches 30.

All three were found in the open in dry, rocky situations; one at dusk, one about two hours after sunset, and one about an hour after sunrise. One had eaten a gray whiptail (*Cnemidophorus t. marmoratus*).

NATRIX ERYTHROGASTER TRANSVERSA Hallowell. BLOTCHED WATER SNAKE. Hot Springs (UMMZ), Boquillas (LPZ). In the Big Bend, evidently restricted to the Rio Grande and its permanent tributaries.

The belly in both specimens was almost white shading to pale flesh color on the underside of the tail. There is no dark pigment at the edges of the ventrals. A preserved female has 139 ventrals, 65 subcaudals, and 36 body blotches. The anal is undivided.

THAMNOPHIS CYRTOPSIS Kennicott. BLACKNECKED GARTER SNAKE. Base of Rosillos Mtns. (CNHM 2, UMMZ, LPZ), Boot Spring, Chisos (UMMZ 2), Chisos Basin (SAM), 3 mi. s. Alpine (DOR), 19 mi. s. Alpine (DOR). Also Terlingua, Glenn Springs, San Vicente (Brown). Chiefly found in wooded canyons and near springs to altitudes of about 7000 feet.

According to Milstead (1953) the Big Bend population is intermediate between the subspecies *cyrtopsis* and *ocellata*. All but one of the specimens collected show prominent dark spots on the side of the neck. The median stripe in life is pale orange shading to yellow posteriorly. Ventrals 165–175 (mean 169.3); subcaudals in males 83, 84; in females 73, 76 (2), and 78.

In late July, almost every pool in the little canyon below Boot Spring was occupied by 2 to 6 of these snakes. They were sunning on rocks or swimming in pursuit of *Hyla arenicolor* tadpoles which were found in the stomachs of those collected. The specimens observed in the Rosillos were found at night or late in the evening. Here on June 29, I collected two very small ones about 8 inches in total length and probably only a few days old. This suggests an autumn or winter breeding season.

THAMNOPHIS MARCIANUS NIGROLATERIS Brown. WESTERN CHECKERED GARTER SNAKE. 12 mi. e. Alpine (CNHM), 5 mi. s. Marathon (CNHM), n. base Rosillos Mtns. (UMMZ), Hot Springs (LPZ). Schmidt and Smith list several other localities along the Rio Grande. Characteristically inhabits lower altitudes than *T. cyrtopsis*.

The specimens from near Marathon and Alpine have a strongly checkered pattern and pale orange median stripe; those from the Rosillos and Hot Springs are less checkered and have grayish white stripes. Ventrals in males 158, 162; tails incomplete. Female has 156 ventrals, 67 subcaudals.

This snake was collected near prairie ponds and the margins of permanent streams. It was not found in the wooded draws and canyons that are good habitat for *T. cyrtopsis*, however both species were taken in damp grassland.

SONORA SEMIANNULATA BLANCHARDI Stickel. TRANS-PECOS GROUND SNAKE. Oak Spring, Chisos (UMMZ), n. base Rosillos Mtns. (UMMZ, CNHM),

3½ mi. s. Persimmon Gap (SAM), 1½ mi. w. National Park Headquarters (SAM), 6 mi. n. National Park Headquarters (SAM). Recorded from numerous desert and semidesert localities from the Rio Grande to Green Gulch at about 5000 feet (Stickel, 1938).

Three varieties were observed. The unicolor phase is light olive to mouse gray above, the centers of the scales darker than their edges and the top of the head slightly darker than the body. The black capped phase is pale orange with the centers of the scales a little darker than the edges and the top of the head grayish brown to black, contrasting sharply with the body color. The ringed phase is light buff with dark brownish gray crossbands extending to the edges of the ventrals. All the specimens collected are males. Scale counts are as follows: Dorsal scales 17–15–14 (3), 17–13–14 (1) or 16–15–13 (2); ventrals 146–153 (mean 150.3); subcaudals 53–59 (mean 57.1).

All these snakes were in arid, open situations in the flats or foothills. The first one was taken March 14 lying in the open about sunset. One seen July 18 was crawling rapidly in the full afternoon sun and disappeared into a crevice. All others were taken at night.

FICIMIA CANA Cope. WESTERN HOOK-NOSED SNAKE. Not collected. Reported from the Chisos (Schmidt and Smith) and from 1 mi. w. Alpine (Wright and Wright, 1957, p. 285). Evidently frequents rocky places at altitudes of 4000 feet or more.

TANTILLA ATRICEPS Gunther. MEXICAN BLACKHEADED SNAKE. Chisos Basin (CNHM 2, UMMZ, INHS), Panther Peak (SAM). All Big Bend records are from the Chisos from the lower limit of the pinon forest to at least 6200 feet.

Ventrals in males 135, 137, 138; subcaudals 63, 64; ventrals in females 148 and 152. Tails incomplete in three. In life, the center of the belly is vermillion shading to pearly white on the throat and chin.

First taken March 4 when temperatures in the Chisos were decidedly cool for snakes. All were under rocks in shaded situations except one found dead on the highway after a rain. The stomach of one contained a beetle larva, another contained a centipede. In both cases the prey was quite large in proportion to the size of the snake. A female collected June 1 contained one large egg nearly ready for deposition.

TANTILLA CUCULLATA Minton. BIG BEND BLACKHEADED SNAKE. 6 mi. sse. Alpine (CNHM).

This specimen has been described in detail elsewhere (Minton, 1956). The dark color of the head involves most of the chin and labials, there is no light collar, and the subcaudal count is 82.

Collected on the highway about an hour before sunset and following a light rain. The terrain where it was taken is hilly and the soil a comminuted reddish lava. The vegetation consists of sparse short grass with a little juniper and cholla.

HYPSIGLENA TORQUATA OCHRORHYNCHA Cope. SPOTTED NIGHT SNAKE. North base Rosillos Mtns. (CNHM, UMMZ, SAM), 4½ and 6½ mi. n. National Park Headquarters (CNHM), 1½ mi. w. National Park Headquarters (CNHM), 6 mi. n. Persimmon Gap (CNHM). Also Glenn Springs, Terlingua, and localities in the Chisos foothills (Brown). Apparently of general occurrence in desert and foothills to about 4000 feet.

Ventrals in 4 males 163–174, subcaudals 49–59; ventrals in 3 females 172–177,

subcaudals 41–52. The nape blotch is 7–12 scales long and there are 50–61 median body blotches. All have 21 scale rows at midbody, 17 or 16 at the vent.

These snakes were taken in both creosote bush and lechuguilla associations, chiefly in rocky places but occasionally in sandy washes. The first one was obtained March 21. It had been killed by a house cat and apparently was abroad in mid-morning. Another was found about an hour before sunset under a piece of metal. It had just eaten an adult ground uta (*Uta stansburniana*). The others were collected at night. The stomach of one contained lizard eggs.

TRIMORPHODON VILKINSONI Cope. TEXAS LYRE SNAKE. Not collected. Degenhardt and Steele (1957) report it from the Chisos Basin and Grapevine Hills. Their specimens were found crawling in the open at night, one on the road, the other on bare ground near an adobe house.

ANCISTRODON CONTORTRIX PICTIGASTER Gloyd and Conant. TRANS-PECOS COPPERHEAD. Northwest side Rosillos Mtns. (INHS, SAM, UMMZ, LPZ 4). Also Alpine and localities in the Chisos (Gloyd and Conant).

Ventrals in males 148, 149; subcaudals 60 (25 divided) and 58 (33 divided). In female, 147 ventrals, 56 subcaudals (30 divided). Two have 13 dark bands on the body and one 14.

All these snakes were taken within an area of a few hundred yards in a small canyon traversed by a spring-fed stream and forested with walnut, oak, Mexican buckeye, and other mesophytic plants. On April 16 about mid-morning, I saw the first two copperheads intertwined in a rock crevice. All others were taken at night. One had eaten a mouse (*Peromyscus* sp.). They seemed inoffensive snakes, gliding away at the approach of a light and not attempting to bite until pinned down.

A captive specimen in the Lincoln Park Zoo gave birth to young during the first week of August.

Toxicity of venom as measured by the subcutaneous L.D. 50 for mice is 22.8 mg. per kilo in contrast with 25.65 mg. per kilo for the eastern copperhead (*A. c. mokeson*). The difference is probably not significant.

CROTALUS ATROX Baird & Girard. WESTERN DIAMONDBACK RATTLESNAKE. Base of Rosillos Mtns. (UMMZ 3, LPZ 2, SAM 2), 4 mi. s. Persimmon Gap (CNHM) 11 mi. n. Persimmon Gap (CNHM), 23 mi. s. Alpine (CNHM), 8 mi. nw. Hot Springs (CNHM). Characteristic of the desert flats but occurs in the foothills to about 4000 feet; also found in the prairie.

These are pale greyish brown snakes with darker rhombs narrowly edged with white. There is often a pale orange wash over the posterior part of the belly. Dorsal rhombs number 28–38 (mean 32.4). Ventrals number 168–182 (mean 177.6); subcaudals in 6 males 21–26, in 3 females 18–20. Scale rows at midbody 25 in 8 specimens, 23 in one.

Diamondbacks from the Big Bend are smaller than those in central and southern Texas. Our largest measured 45 inches, and a 35-inch female was gravid. Residents say they rarely find diamondbacks as much as four feet in length.

Diamondback rattlesnakes were found in open desert, about low, rocky bluffs, and in a grassy pasture. They were first seen March 9. Those collected during March and early April were in the open during the day; later they were taken at night or shortly before sunset. Most were irritable, savage snakes when cornered, although the initial reaction of nearly all was flight rather than combat. One adult snake had eaten a large pack rat (*Neotoma albigula*); a smaller snake had eaten an unidentified rodent. Gravid females were collected May 14 and June 26.

CROTALUS LEPIDUS LEPIDUS Kennicott. MOTTLED ROCK RATTLE-

SNAKE. Emory Peak, Chisos (SAM), Rosillos Mtns. (UMMZ), 3½ mi. sw. Alpine (CNHM). Characteristic of rocky areas 4700 to 7500 feet elevation.

A male has 159 ventrals, 26 subcaudals; ventrals in females 157, 160; subcaudals 21 and 20. The ground color in life was light reddish brown to drab gray or olive.

These snakes were obtained near rock slides and ledges coiled in the open in daylight. All were found on overcast days or after rain. They seem less nocturnal than the other local rattlesnakes. A very small one, 183 mm. in total length and apparently only a few days old, was collected August 4. One taken near Fort Davis and sent to the Lincoln Park Zoo gave birth to 3 young on August 23.

The venom is moderately toxic, the L.D. 50 for mice being 11.55 mg. per kilo.

CROTALUS MOLOSSUS MOLOSSUS Baird & Girard. BLACKTAILED RATTLESNAKE, GREEN RATTLESNAKE. Rosillos Mountains (CNHM 3, LPZ SAM), 2 mi. s. Government Spring (UMMZ), Croton Spring, Chisos Foothills (UMMZ). Apparently most plentiful in the foothills and mountains to about 6000 feet but have been recorded from the Rio Grande valley to the higher slopes of Emory Peak.

Ground color ranges from steel gray to greenish gray. Dorsal scale rows at midbody 27 in 6, 29 in one; ventrals 179–190 (mean 185.0); Subcaudals in 5 males 23–27, in 1 female 20. Dark transverse body bands 29–38 (mean 31.8).

Most were collected in rocky places. They are sometimes found in rock slides but show less preference for this habitat than *C. lepidus*. Two were obtained in a pasture at the base of the Rosillos associated with *C. atrox* and *C. scutulatus;* apparently the blacktails stray into this site from nearby limestone bluffs. One found here had eaten a young pack rat. These rattlesnakes were collected by day about as frequently as at night. They are generally rather mild tempered, but the disposition of individuals varies greatly. Most will strike when cornered, but they do not adopt the spectacular defensive pose of the diamondback.

The venom is of moderate toxicity, the mouse L.D. 50 being 17.4 mg. per kilo.

CROTALUS SCUTULATUS Kennicott. MOJAVE RATTLESNAKE. North base Rosillos Mtns. (CNHM, SAM), 5 mi. s. Marathon (UMMZ). Also Hot Springs and Persimmon Gap (Brown). Occurs in desert and grassland below 4000 feet.

Ground color of fresh specimens greenish gray; 34 to 35 (2) olive brown rhombs with distinct white edges. Scale rows at midbody 23 in two specimens, 25 in one. Ventrals in males 168, 173; subcaudals 25, 26. A female has 174 ventrals, 18 subcaudals.

Two Mojave rattlers were found in the early morning, one late in the afternoon. One was found in a grassy pasture, one in creosote bush flats adjoining the pasture, and one in the grassland desert transition zone. A female collected July 4 was gravid.

An extremely toxic venom sample was obtained from one of these snakes. The L.D. 50 for mice is 0.31 mg. per kilo, about ten times as toxic as any other North American pit viper venom I have tested.

CROTALUS VIRIDIS VIRIDIS Rafinesque. PRAIRIE RATTLESNAKE. 5 mi. n. Alpine (DOR). Also 5 mi. e. Marathon and Big Bend Park (Brown). Occurrence rare and spotty, mostly in grassland.

The snake observed near Alpine was putrid and partly devoured by scavengers. There were at least 30 dark body blotches with narrow, distinct light edges. In view of the scarcity of this species in Trans-Pecos Texas, the following data from a specimen collected 5 miles east of Van Horn by Madge and Brooks Minton may be

worthy of record. This snake is a male with 25 scale rows at midbody, 181 ventrals, and 26 subcaudals. The ground color of the fresh specimen was light greyish brown with 34 distinct reddish blotches narrowly margined with cream and 9 alternating light and dark rings on the tail.

ACKNOWLEDGMENTS

It was the late Karl P. Schmidt who first pointed out to me the desirability of a prolonged field study in the Big Bend Region. Mr. Schmidt followed this project with lively and sympathetic interest and, with a party from Chicago Natural History Museum, joined me briefly in the field during April. Permission to collect in Big Bend National Park was generously granted by the National Park Service whose personnel were at all times most cooperative. In particular, I wish to thank Park Superintendent George Miller, Assistant Superintendent David Jones, and Chief Ranger George Sholly for the courtesy and kindness shown us. Rangers Earl Steele and Pat Miller aided considerably by collecting specimens and recording their observations of amphibians and reptiles encountered. Especial thanks are due Mr. Olin Blanks of San Angelo, Texas who made available to us a comfortable house on the Rosillos Ranch. To J. Lear Grimmer, formerly of Lincoln Park Zoo, Chicago, and to Roger Conant of Philadelphia Zoo, I am indebted for notes on eggs and young of several snakes collected. Dr. Philip W. Smith of the Illinois Natural History Survey acted as temporary curator of my preserved material and joined in the field work during the first week of June. Ranchers and other residents of the area took a friendly interest in the work and contributed several valuable specimens. Particular thanks are due William and Jesse Dodson, Archie Lee, Sotero Morin, W. A. Gulihur, Clint Shaw, and Frank Woodward. My wife, Madge, and eldest daughter, Brooks, were of great help in collecting, observing, and caring for the material. My younger daughters, April and Holly, proved diligent toad and lizard hunters.

LITERATURE CITED

BORRELL, A. D. and M. D. BRYANT. 1942. Mammals of the Big Bend area of Texas. Univ. Calif. Pub. Zool., 48: 1–62.

BROWN, B. C. 1950. An annotated list of the reptiles and amphibians of Texas. Baylor University Press, 257 pp.

BURGER, W. L. 1950. New, revised, and reallocated names for North American whiptailed lizards, Genus *Cnemidophorus*. Nat. Hist. Misc. No. 65, 9 pp.

DEGENHARDT, W. G. and G. E. STEELE. 1957. Additional specimens of *Trimorphodon vilkinsoni* from Texas. Copeia, no. 4, pp. 309–10.

GLOYD, H. K. and R. CONANT. 1943. A synopsis of the American forms of *Agkistrodon* (copperheads and moccasins). Bull. Chi. Acad. Sci., 7: 147–170.

JAMESON, D. L. and A. G. FLURY. 1949. Reptiles and Amphibians of the Sierra Vieja. Tex. Jour. Sci., 1 (2): 54–79.

KLAUBER, L. M. 1940. The worm snakes of the Genus *Leptotyphlops* in the United States and northern Mexico. Trans. San Diego Soc. Nat. Hist., 9: 87–162.

————. 1946. The glossy snake, *Arizona*, with descriptions of new subspecies. Trans. San Diego Soc. Nat. Hist., 10: 311–318.

————. 1947. Classification and ranges of the gopher snakes of the Genus *Pituophis* in the western United States. Bull. Zool. Soc. San Diego No. 26, 143 pp.

LEWIS, T. H. 1950. The herpetofauna of the Tularosa Basin and Organ Mountains of New Mexico with notes on some of the ecological features of the Chihuahuan Desert. Herpetologica 6: 1–16.

MASLIN, T. P. 1953. The status of the whipsnake, *Masticophis flagellum* (Shaw) in Colorado. Herpetologica, 9: 193–200.

MILSTEAD, W. W. 1953. The subspecies of the garter snake, *Thamnophis cyrtopsis*. Tex. Jour. Sci., 5: 348–379.

————. 1957. A reconsideration of the nomenclature of the small whiptail lizards, *Cnemidophorus*, of southwestern Texas. Copeia no. 3, pp. 228–229.

————, J. S. MECHAM, and H. McCLINTOCK. 1950. The amphibians and reptiles of the Stockton Plateau in northern Terrell County, Texas. Tex. Jour. Sci., 2 (4): 543–562.

MINTON, S. A. 1956. A new snake of the Genus *Tantilla* from west Texas. Fieldiana Zool., 34: 449–452.

MURRAY, L. T. 1939. Annotated list of reptiles and amphibians from the Chisos Mountains. Contr. Baylor Univ. Museum, No. 24, pp. 4–16.

PHELAN, R. L. and B. BRATTSTROM. 1955. Geographic variation in *Sceloporus magister*. Herpetologica, 11: 1–14.

SCHMIDT, K. P. 1953. A checklist of North American amphibians and reptiles. Amer. Soc. Ichthyologists and Herpetologists, Chicago, Ill., pp. i-viii, 1–280.

————, and T. F. SMITH. 1944. Amphibians and reptiles of the Big Bend region of Texas. Zool. Ser. Field Museum Nat. Hist., 29: 79–96.

SMITH, HOBART M. 1946. Handbook of Lizards. Comstock Publishing Co., Ithaca, N. Y., pp. i-xxi, 1–555, pl. 1–135.

————. 1947. Subspecies of the Sonoran Toad (*Bufo compactilis* Weigmann). Herpetologica, 4: 7–13.

SPERRY, O. E. and B. WARNOCK. 1941. Plants of Brewster County, Texas. Sul Ross State Teachers College Bull., 22 (1): 17–60.

STICKEL, W. H. 1938. The snakes of the Genus *Sonora* in the United States and Lower California. Copeia, no. 4, pp. 182–190.

TINKHAM, E. R. 1948. Faunistic and ecological studies on the Orthoptera of the Big Bend region of Trans-Pecos Texas. Amer. Midland Nat., 40: 521–663.

WRIGHT, A. H. and A. A. WRIGHT. 1949. Handbook of frogs and toads of the United States and Canada. Comstock Publishing Co., Ithaca, N. Y., pp. i-xii, 1–640, pl. 1–126.

————, and ————. 1957. Handbook of snakes of the United States and Canada. Comstock Publishing Co., Ithaca, N. Y., Vol. I, i-xviii, 1–564; Vol. II, i-ix, 565–1105, 304 figs.

THE SOUTHWESTERN NATURALIST 3: 55–69 1958 (PRINTED 1959)

VARIATIONS IN THE MOUTH PARTS IN TADPOLES OF *SCAPHIOPUS* (SPEA) *BOMBIFRONS* COPE (AMPHIBIA: SALIENTIA)

ARTHUR N. BRAGG AND WILLIAM N. BRAGG

Oklahoma Biological Survey, University of Oklahoma, Norman

ABSTRACT. Tadpoles of *Scaphiopus bombifrons* were studied in pools and several cannibalistic individuals observed. Variation in mouth parts of several hundreds of preserved tadpoles indicated the following tendencies in the cannibalistic type: (1) greater overall variation; (2) loss of dental row 1; (3) closure of the dorsal papillary gap; (4) reduction in number from two to one papillary rows; (5) presence of smaller and finer labial teeth in some rows; and (6) formation of distinct lips. It is emphasized that all of these are tendencies, not absolutes, and that there are many variations and intermediate conditions, some of which are described. The labial formula in 402 specimens varied from 0/0 to 6/6 with the most frequent value 4/4.

Orton (1954) interpreted the pertinent observations of Gilmore (1924), Smith (1934), Bragg (1941, 1946, 1948), Stebbins (1951), and Turner (1952) as indicating dimorphism in tadpoles of the *hammondi*-group of spadefoots, associated with predacious cannibalism. At least some members of the group produce two kinds of tadpoles: (1) smaller, round-bodied individuals with normal sized jaw muscles, no marked beak in the upper jaw and no corresponding notch in the lower, and no tendency to be predaciously cannibalistic; and (2) individuals larger at the same age, narrower bodied, with marked beak/notch relationship in the jaws and predaciously cannibalistic on their fellows. Various intermediates of unknown feeding habits have also been noted (Bragg, 1946, 1948; Stebbins, 1951; Turner, 1956). Orton especially, has emphasized that the geographic distribution of these tadpole types varies greatly.

Bragg (1957) confirmed Orton's interpretation for *Scaphiopus bombifrons* Cope from Tillman County, Oklahoma. There now appears to be no question that this (and probably other) species of the subgenus Spea manifests the phenomena in question. The geographic variations suggest a genetic basis with the genes involved unevenly distributed in the population. It would seem that so complex a problem will take many years of work by many individuals, since apparently the genes of Scaphiopus are wholly unknown.

A good starting point seems to be a study of the variations, especially in the mouth parts, of tadpoles of the one certainly known dimorphic species, *S. bombifrons* Cope. Fortunately, the Stovall Museum of Science and History of the University of Oklahoma has a large collection of these tadpoles, mostly from Oklahoma but with a few from surrounding states. The geat majority of these were collected by the senior author between 1945 and 1956 while working on the Oklahoma Biological Survey. Accordingly, exact collecting sites are known and in many cases the pools where the tadpoles were developing are remembered well.

We have extensively sampled this collection for variation in mouth parts. In addition, we took a trip of just over 600 miles into southwestern Oklahoma in the spring of 1957 to study live tadpoles in nature and also to make collections in areas from which none of these tadpoles were previously known. This paper presents our findings.

METHODS

The tadpoles were divided into three groups: I. Those judged to have jaws with essentially no beak and notch; II. Those intermediate in these characters (beak with no notch, notch with no beak, weak development of both, etc.); and III. Those judged to have a well developed beak and notch in the jaws. The first and third groups were easily distinguished from each other whereas the second group contained some which others might have put into one of the other groups. The variations are such that grouping of intermediates is a matter of judgment.

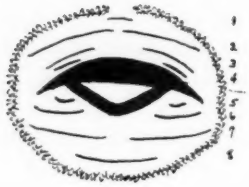
Many tadpoles were scanned, some alive, others preserved, for minor variations and certain individuals were picked out for more detailed study and measurement. To minimize error, all measurements were made by the same worker. The following were determined: (1) head-body length; (2) total length; (3) tail length (some secured indirectly by subtraction); and (4) chord length of each row of labial teeth, essentially following Nichols (1937). When labial teeth rows were divided, showing a gap in the middle, two chord lengths were taken, (a) that of the right side and (b) that of the left. In cases where individual teeth of a row were missing, this was disregarded in the chord length measurement provided that the ridge on which the teeth develop was not also interrupted. This assumes, of course, that the presence of the ridges is more fundamental than the mere presence of teeth which are known to be easily lost. Since the ages of the tadpoles were usually unknown, we report only on well

developed individuals, some of them nearing metamorphosis. Due care was taken in the older ones especially to avoid error due to loss of labial teeth associated with metamorphic changes. A binocular microscope was used for observations while the preserved animal was depressed in alcohol-soaked cotton in a Syracuse watch glass. Live tadpoles were held down on water saturated cotton. Chord lengths were obtained on the preserved specimens by use of an occular micrometer, calibrated for the particular set of lenses used and capable of measuring to 0.0588 mm. We found specimens in which some of the teeth rows varied so much as to make it unsound to attempt measurements of a particular row or part row (i.e., a or b). In calculating means from the measurements, therefore, the number for any one row does not necessarily correspond to the total number of animals contained in a given group. For this reason, also, the right and left sides of divided rows (a and b) were calculated separately.

OBSERVATIONS

It soon became evident that, despite the many variations mentioned later, there is a characteristic pattern (Fig. 1). The labial formula of this is 4/4. The first upper row is short and undivided, the second divided in the middle by a narrow gap, the third still further divided, the fourth more so. The lower rows are reversed in these respects, the lowermost the only one undivided across the midline and, over all, the shortest. The papillary fringe typically consists of a double row of papillae but may be made of a simple row.

Variations from this typical pattern are numerous and differ considerably from group I to group III. These are some of the minor variations seen in 102 specimens; one individual had a short row of papillae replacing the first row of labial teeth. Another specimen had an extra row almost exactly comparable to row 1 below row 2 (Fig. 2A). A third had row 1 represented twice, i.e., there were two short rows beneath the papillary gap where row 1 usually occurs (Fig. 2B). In many specimens, no median gap occurred in some of the longer rows where it would be expected from our description of the "typical" condition. In several, a dental row was represented on one side only. Others had rows running into each other in varying degrees. Several had pigmented areas near lacking rows, especially dorsally (Fig. 4). In a few specimens, extra labial teeth were irregularly placed. In a few, the papillae ran into a row of labial teeth. The labial formulae varied from 0/0 to 5/5 in the 102 specimens, counting all groups together. Those with 5/5 all had extra, widely divided, short rows added



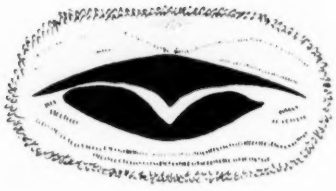


Fig. 1. Diagram of "typical" pattern of mouthparts of *S. bombifrons* based upon the visual conditions seen in specimens of group I (see text). Labial teeth rows represented by lines.

Fig. 2. A. Upper labium of a 40 mm. tadpole of group I from Marshall County, Oklahoma showing an extra row, comparable to row 1, below row 2.

B. Upper labium of a 39 mm. tadpole from Major County, Oklahoma. Row 1 is doubled, row 2 has teeth unusually placed in the median gap and has row 4 partly represented. This specimen was also exceptional in that the lower jaw was not serrate.

C. The outer portion of the upper labium of a specimen of group III from Cimarron County, Oklahoma. The papillary gap is barely present and row 1 is lacking.

D. The outer portion of the upper labium of a 33 mm. specimen of group III from Beaver County, Oklahoma showing row 1 divided. This condition is quite exceptional.

Fig. 3. Mouth parts of a 14 mm. tadpole of group I from Dewey County, Oklahoma illustrating quite exceptional conditions for this group. Compare with Figure 1.

Fig. 4 Mouth parts of a 54 mm. tadpole of group III from Tillman County, Oklahoma. A pigmented area (stippled) is substituted for row 1. Rows 2 and 3 are indistinct and interrupted. The ventral rows are all present and distinct but row 7 has indistinctly seen small teeth in place of the usual median gap.

to the dorsal set at the bottom and to the ventral set at the top, i.e., between rows 4 and 5 as shown in Fig. 1. Often one or both of these were represented on one side only.

That this is not the natural limit of variation in number of labial rows is indicated by data on 300 tadpoles of *S. bombifrons* collected in Oklahoma, for which we are indebted to Dr. Jack Bresler of Brown University who made the counts and graciously permits us to report. The distribution of labial formulae found was as follows: 2/2 = 1; 3/2 = 3; 2/4 = 7; 3/3 = 16; 3/4 = 56; 3/5 = 1; 3/6 = 2; 4/3 = 14; 4/4 = 128; 4/5 = 20; 4/6 = 1; 5/2 = 1; 5/3 = 1; 5/4 = 27; 5/5 = 9; 5/6 = 1; 6/4 = 7; 6/5 = 3; 6/6 = 2. Combining the two sets of data we have a known labial formula range in 402 specimens of 0/0 to 6/6, with 4/4 the most frequent finding.

Our chief concern was to study characteristic major variations in our groups I and III, the latter representing the cannibalistic tendencies already mentioned. Our field observations indicated that tadpoles classified as group I predominate in nature. In a series of ditches of clear, shallow water in Beckham County within a mile of a site from which some of group III were collected earlier, no tadpoles of thousands present had the characteristic flat-headed appearance and larger size of cannibalistic tadpoles of this species (Compare Fig. 9A and C); and no cannibalism was observed here. In contrast, in a long clear-water ditch in Washita County, just west of Cordell, such individuals were present and were seen to catch and kill other tadpoles (Fig. 9A). But we had to observe carefully to find them, there were so few of them there. In turbid pools in Tillman County, blind sweeping caught hundreds of the usual type (comparable to group I) but only an occasional cannibal (group III). The comparative rarity of the type of group III is confirmed by many former experiences with these tadpoles and is probably the reason that dimorphism was not earlier noted, even in regions where it occurs. Two pools containing well developed tadpoles in Cleveland County near Norman were also carefully studied but we still found no clear-cut member of group III although we did find one intermediate (group II), a tadpole with weakly developed beak and notch but with nothing else to suggest that it might have been either dimorphic or cannibalistic (cf. Trowbridge, 1942).

Of the 102 tadpoles selected for detailed study, 50 were in group I, 15 in group II, and 37 in group III. These ranged respectively in total length from 13.5–60.0, 18.0–63.0, and 26.0–76.0 mm. with corresponding means of 36.9+, 34.6+ and 57.1− mm. (N = 49 in group I in tail and total lengths because of a broken tail in 1 specimen). Labial formulae in these three groups varied as follows expressed to the nearest 0.1%: Group I; 0/0 = 2.0%; 2/3 = 4.0%; 2/4 = 2.0%; 3/3 = 20%; 3/4 = 24.0%; 4/4 = 36.0%; 4/5 = 6.0%; 5/5 = 4.0%; 5/5 =

4.0%. Group 2: 2/3 = 20.0%; 2/4 = 6.7%; 3/3 = 13.3%; 4/3 = 6.9%; 4/4 = 21.9%; 4/5 = 26.7%; 4/5 = 6.7%; 5/5 = 6.9%. Group III: 1/2 = 3.1%; 2/3 = 18.8%; 2/4 = 25.0%; 3/4 = 28.0%; 4/4 = 21.9%; 4/5 = 3.1%.

The modal number in groups I and II was the same (4/4) but it was 3/4 in group III. This is a reflection of the absence of the row I of labial teeth on many specimens in group III. We thought that it might be instructive in view of so much variation to derive a sort of "mean" labial formula for each group by calculating the means for the number of upper and lower rows and expressing them in the usual way as a fraction. The results follow, given to the nearest 0.1; I, 3.6/3.9; II 2.3/3.7; III, 2.8/3.6. Despite the fact that one exceptional individual in group I had 0/0 and thus pulled the numbers lower, this more "typical" group emerged with a significantly larger number of labial rows than group III. The larger individual sizes in group III precludes the possibility that this result might be due to immaturity and we were especially wary of possible loss due to metamorphic changes. Accordingly, we conclude that one of the specializations associated with the development of large jaw muscles, a beak and notch in the jaws and cannibalistic habits is a tendency to reduce the number of rows of labial teeth.

This is further shown by another obviously closely related phenomenon. In the majority of individuals in group I, the individual labial teeth as seen under a binocular microscope are individually dark, rather large and distinct. In contrast, those of group III are characteristically small, not sharply contrasted by color and indistinct. There are, however, exceptions in both groups. Also, especially in group III, intermediate conditions in some rows occur, i.e., teeth darker, larger and more distinct in some rows than in others in the same individual. No consistent tendency was noted, and there apparently is none, for the teeth of any one row to be darker, larger, or more distinct than others throughout the series of individuals. But there is a clear tendency within individuals to have the teeth in all rows dark, large, and distinct or to have none of them this way. Since we worked mostly with preserved tadpoles, this appearance might be due to an artifact. We do not think so for the following reasons: (1) some specimens were seen in which only (and all) of the teeth dorsally (or ventrally) showed these characteristics; and (2) the differences were obvious between groups I and III, both of which were preserved. It would seem that preservation would not make changes differently in different rows of teeth in a single individual (nor more or less con-

sistently between groups) especially since in many cases members of groups I and III were from the same collections and thus subjected to the same strength of the same preservatives. We conclude, therefore, that another specialization of the cannibalistic *S. bombifrons* tadpole is a tendency for the labial teeth to be individually small and difficult to see.

Figures 1 and 7 indicate that in the "typical" tadpole of *S. bombifrons* a short gap occurs dorsally in the papillary fringe. This gap is sometimes absent. We tested the frequency of its presence in our contrasting groups and found it approximately as follows: (omitting fractions) I. present in 82%, absent in 17% of 43 individuals; II. present in 73%, absent in 27% of 15 individuals; III. present in 43%, absent in 57% of 35 individuals. In comparing the first and third groups, these figures clearly indicate a tendency for closing this dorsal gap in the papillary fringe in tadpoles of the cannibalistic type. This is further shown by a few individuals in group III which actually had the gap present but proportionally covering a much smaller area than usual. In one, not more than four or five papillae could have been put into the space; in another, only one or two (Fig. 2C). In this second one of these, we considered for some time as to whether to call the gap present at all but finally did so. In the other group, the gap, while varying somewhat in extent, was always clearly present or absent.

In some individuals, especially in group III, other gaps in the papillary fringe occurred. Most of these seemed to have little significance except as minor variations but there was one marked exception. Six individuals of group III (and none in the other groups) had symmetrically placed breaks in the papillary fringe at the sides of the mouth, with the areas lacking papillae depressed, so that the whole gave the appearance of two distinct lips, dorsal and ventral (Fig. 6). One of us (A.N.B.) has noticed this condition earlier in several *S. bombifrons* from Oklahoma. These specimens had extreme development of jaw muscles, and jaws with a large beak and notch. This condition was also seen in several others of this type (taken then to be *S. h. hammondi*) from Las Vegas, N.M. and from Colorado (Bragg, 1941) but not mentioned specifically in that report. It would seem therefore that this tendency to form lip-like areas over the mouth, through development of depressed areas devoid of papillae at the sides, is another characteristic of the cannibalistic individual, especially of the extreme type.

As earlier indicated, the papillary fringe may be made of a single or of a double row. The incidence of this character in our groups was

as follows: I. single, 36%, double, 64%; II. single 53%, double 40%, double above and single below, 7%; III. single 56%, double 24%. In addition, several in group III had minor developments of extra papillae, sometimes in patches on the inner surface of the "lips", occasionally as single papillae beside the general papillary fringe or more often as short extra rows there.

From these facts it seems that, (1) predacious cannibalistic feeding in *S. bombifrons* tadpoles involves a tendency to a reduction in the papillary rows accompanied by (2) variability in the location of "extra" papillae.

As indicated in Fig. 1, eight rows of labial teeth seem more consistently present than others. Just how consistent are they and how does this compare in our groups?

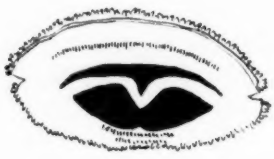


Fig. 5. A vry peculiar variation in mouth parts of a 37 mm. tadpole of group III from Jackson County, Oklahoma.

Fig. 6. Mouth parts of a group III tadpole from Tillman County showing most of the conditions mentioned in the text as tendencies in the cannibalistic type, including the development of distinct lips.

Fig. 7. Drawing of the mouth parts of a nearly typical 20 mm. tadpole of group 1. This animal, apparently, was too young to have developed rows 4 and 5 (compare Figure 1). The specimen came from Harper County, Oklahoma.

Fig. 8. Mouth parts of a 33 mm. tadpole of group III from Jackson County, Oklahoma. It shows narrow but heavy jaws and reduction in the labial rows but no "lips."

Row 1 was present in 29 out of 42 individuals (approximately 71%) in group I; in 4 out of 6 (67%) in group II, and 12 out of 27 (44%) in group III. This reduction in the incidence of row I in group III is closely correlated with a corresponding reduction in the incidence of the dorsal papillary gap, mentioned earlier (Figs. 3, 4, 5, 6, and 8). However, a few exceptions were found. Row 2 is not correspondingly reduced in incidence. It was 100% present in all groups except the single individual of group I which lacked labial teeth. Row 3 is not reduced (found to be 94%, 100%, 100% present in the groups respectively). Row 4 varies more (76%, 33%, and 37.5% present) and, again, in the direction of a reduction from groups I to III. This also pertains to row 5 (89%, 50%, and 71% present). Rows 6, 7, and 8 show no real reduction. The incidences found for these were as follows: row 6, 97%, 100%, and 96% respectively; row 7, 100% in all groups; row 8, 97%, 100%, and 100% present.

From these facts it seems clear that adaptations toward predacious cannibalism involve a tendency to reduce the incidence of rows 1, 4, and 5 but not of any of the other rows. In considering this, it should be recalled, however, that even though present, the teeth in any row, especially in group III, *may* be reduced in size and pigmentation (Figs. 3, 4, 5, 6, and 8).

As indicated (Fig. 1) all dental rows except 1 and 8 characteristically have median gaps in progressing degrees dorsally (i.e., from rows 2 to 4) and in regressing degrees ventrally (i.e., rows 5 to 7). Sometimes these gaps are lacking (Fig. 7 shows row 7 undivided). How do the groups compare in this? Row 1 was without a median gap in all specimens except one in group III where it was represented by a few teeth on either side of the mid line. This exception might be a reflection of the general tendency to eliminate this row but it might just as well be the result of an injury. Row 2 lacked the gap in 5 out of 34 in group I (approximately 15%); none in group II (only 6 individuals); and 6 out of 24 (25%) in group III. This is an interesting result. It seems to show a tendency in the cannibalistic group to compensate for the gradual loss of row 1 by filling in the gap in row 2 immediately below. But this does not seem consistent with the tendency shown to have the labial teeth smaller and finer among these than in the "typical" members of the species (represented most clearly by group I). In row 3, the gap was lacking in only one individual (of group III). Two other individuals of this group had the row represented on one side only. Row 4 had the gap present in 24 individuals of group I with two others having the row represented only on

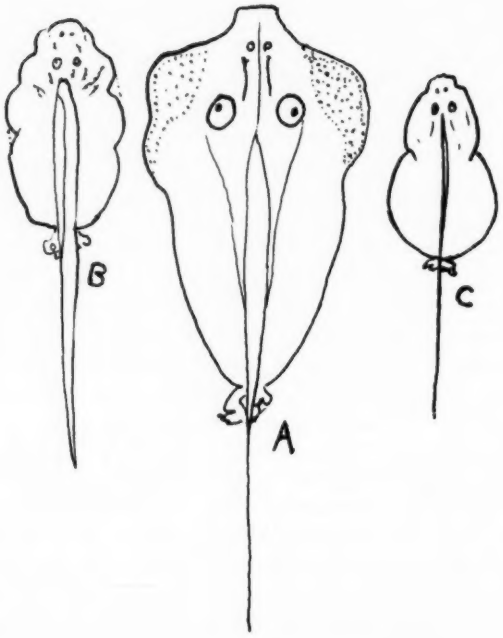


Fig. 9. Comparison of three types in S. *bombifrons* tadpoles drawn to same scale.

A. Extreme cannibalistic type (group III) from Washita County, Oklahoma: showing (a) very large size, (b) extremely hypertrophied jaw muscles and (c) short tail. This animal was seen to attack and eat other smaller tadpoles in the pool before its capture. Its total length (alive)=61.5 mm. Age unknown.

B. The cannibalistic tadpole mentioned by A. N. Bragg (1957). This animal was somewhat larger than its fellows of the same age, had some hypertrophy of the jaw muscles, typical reduction in labial teeth, and marked beak/notch relation in the jaws. It was collected in Tillman County, Oklahoma. Of the same age as C.

C. A non-cannibalistic individual (group 1). Note rounded abdomen as compared to A (B is intermediate). Specimen from same pool as B and of the same age (Bragg, 1957).

the right side. Only two individuals of group II had this row present, both with the gap occurring. In group III, only a few had this row represented. Of these, three had the typical gap, four had the row represented only on the left and one only on the right. It seems unnecessary to state exact figures for the ventral rows. They were comparable to the dorsal but with reverse positions. In group III, row 7 was comparable to row 2, row 4 to row 5, and row 1 to row 8 except

that the last was most frequently divided in group III and most individuals of all groups possessed it.

Body size as measured by head-body length seemed not to be correlated with presence or absence of medial gaps in the rows. For example, one tadpole of group III with head-body=22.0 mm. had no gap in either row 7 or 8 whereas one of 21 mm. had a typical gap in each.

Table 1 gives chord lengths of each of the principal labial rows and

TABLE 1

Mean values of head-body lengths to nearest 0.1 mm. and of chord lengths of the labial rows as found in groups I, II, and III, (see text) of tadpoles of *Scaphiopus bombifrons*. Rows 1–4 are dorsal; 5–8 ventral. In divided rows, a=chord length on right, b on left, of the median gap. Number in each class is given in parenthesis.

	ROWS								
Group	1	2	3	4	5	6	7	8	Head-body
I a	6.36	1.27	0.70	0.62	0.38	0.63	0.98	1.07	17.0
	(29)			(26)	(31)			(31)	(50)
b		1.30	0.77	0.37	0.37	0.58	0.98		
II a	0.39	0.98	0.59	0.45	0.32	0.57	0.91	1.07	15.0
	(4)								(15)
b		0.95	0.56	0.47	0.33	0.52	0.87		
		(5)	(6)	(2)	(3)	(6)	(3)		
III a	0.35	1.51	0.79	0.26	0.29	0.63	1.00	1.11	22.0
	(11)	(16)	(23)	(6)	(18)	(22)	(9)	(22)	(37)
b		1.52	0.87	0.39	0.32	0.73	1.02		
		(17)	(21)	(4)	(17)	(21)	(8)		

head-body lengths in the three groups, expressed as mean values to the nearest .01 mm. (nearest 0.1 in head-body).

Row 1 has approximately the same mean chord length regardless of body size at least within the limits of the specimens used for this study and it is sometimes actually longer in smaller than in larger individuals. In one tadpole, for example, with head-body = 20.0 mm., row 1 measured 0.3906 mm. whereas another with head-body = 14.0 mm. had row 1 measurement of 0.6138 chord length. One of 18 mm. head-body length had a row 1 chord length of 0.2790; another with 20.0 head-body had a row 1 chord length of 0.2232. These were all of group I and are illustrations of the considerable variation found. Comparing group I with group III one might expect even greater variations in the latter group which apparently represents a reduction in incidence of this row (see above). This is apparently the case. For example, one individual of group III with a head-body length of 18.5 had a row 1

chord length of 0.2232. In three with head-body measurements of 22.0, 25.5, 19.5, the row 1 chord length in each was 0.5022. One with 16.0 mm. head-body had a row 1 chord length of 0.3906. With only 11 specimens in group III, however, the real significance of these figures is not completely clear.

The other "unstable" rows (i.e., 4 and 5) are somewhat shorter in group III than in group I, especially when considered proportionally to body size but the "stable" rows (i.e., 2, 3, 6) do not show this. But in row 8, a mean chord length of 1.07 (31 individuals) and a mean of 17.0 head-body length (50 individuals) is proportionally different from 1.11 (22 individuals) with head-body 22.0 (37 individuals) and the same thing is indicated for row 7 where the mean chord lengths are comparable in groups I and III despite the difference in head-body length. All of this seems to indicate that the chord lengths of some rows tend to reach a maximum value in group III and then fail to develop further with increasing body size. But variations are too numerous in individual chord lengths for this to be certain from the number of specimens used in this study.

Considered geographically, the following distribution was found for the many hundreds of specimens from Oklahoma examined: The "typical" tadpole (group I) was predominant in all collections from a total of 21 counties representing most of the western and central part of the state east to Creek County. Intermediates (group II) are known mostly from the west (Kiowa, Woodward, Texas, Beckham, Greer, Tillman, Harper, and Beaver counties) with one questionable specimen taken in Cleveland County (central Oklahoma). The cannibalistic type (group III) was nowhere predominant, but one or more specimens occurred in collections from many western counties (specifically in Beaver, Cimarron, Texas, Jackson, Woodward, Beckham, Greer, Tillman, Caddo, and Washita counties). But it should be noted that one was found also in a collection from Creek County which is east of the region in Oklahoma where this species is abundant, although it occurs as far east as Tulsa in northern Oklahoma.

Ecologically considered, types of pools seem to make no difference so far as we can find—and we have observed *S. bombifrons* tadpoles in literally hundreds of pools. But it is true that the cannibalistic and intermediate types occur more frequently in the drier and hotter regions (western) than elsewhere in Oklahoma, hence in the western prairies and in the plains.

In habit-differences in natural waters we have only a few notes to offer. At the cite of the Creek County collection mentioned above, the water was very clear in a long shallow ditch swarming with these tad-

poles. Most tadpoles were in social feeding aggregations and our collection was separately taken from both aggregated and non-aggregated tadpoles. No cannibalism was noted here but the few animals of the group III collected were from the non-aggregated animals, and none were taken from the aggregations. Since it is much easier to collect from such aggregations, many more aggregated individuals were collected than those swimming freely outside the aggregated groups; yet it was only among the non-aggregated tadpoles that those of group III were taken. Similarly, in western Oklahoma (with one exception, Bragg, 1946) wherever feeding aggregations have been seen the cannibalistic individuals seem not usually associated with them. Rather, they wander through the pool, for the most part, more or less isolated from their fellows. This was seen specifically by us in only two different places where the water was clear: but that the large, flatheaded type of tadpole is a sort of "lone wolf" among its kind has been noted by one of us (ANB) many times since 1941, long before its interpretation was clear. This would seem to indicate that the instinctive pattern of behavior more or less characteristic of predatory vertebrates has been developed in these predatory tadpoles; and this is a further reason for seeking a genetic basis for the dimorphism shown.

SUMMARY

A study of the variation in tadpoles of *Scaphiopus bombifrons* Cope revealed the following tendencies among those constructed like known predatory cannibalistic individuals as opposed to the more frequent "typical" non-cannibalistic individuals:

1. A beak occurs in the upper jaw with a corresponding notch in the lower (cf. Smith, 1934) although the details of structure vary greatly giving rise to intermediates (Stebbins, 1951; Orton, 1954).
2. Various degrees of hypertrophy of the jaw muscles in association with the beak/notch relationship occur as noted by Gilmore (1924) and various authors since he wrote.
3. Rapid growth rates as compared with that of siblings is characteristic of the predatory cannibalistic type. Hence, at a given age from at least mid-development onward, they are much larger than their fellows in the same water, in extreme cases at least twice as large (cf. Bragg, 1956). There is, however, no evidence that *developmental* rate differs from others in a given pool—i.e., metamorphosis does not start any sooner among the cannibalistic individuals.
4. There is a greater variation in the arrangement of labial teeth.

This results in part from a tendency to lose the first dorsal row and often the inner rows (at least in part) as well.

5. The loss of row 1 is correlated with a tendency to have the median gap in row 2 closed.
6. This is also correlated with a marked tendency to lose the dorsal gap in the papillary fringe and to have this fringe reduced from the typical 2 rows of papillae to one row.
7. In apparent correlation with the loss of labial teeth, those that remain are more often irregularly placed, smaller, less pigmented, and more difficult to see.
8. All of the above tendencies seem clear enough from our study. Nevertheless, one should be warned that they are *tendencies* only —not absolutes—and many exceptions and many minor variations occur.
9. The characteristic labial formula is 4/4 in the species (based on 402 individuals) but nearly all possible variations between 0/0 to 6/6 have been seen. In those recognized clearly as of the cannibalistic type, a slightly larger number had 3/4 rather than 4/4 as might be expected from the greater variation in detail and from the tendency to lose row 1.
10. In Oklahoma, the geographic distribution of the cannibalistic type is more characteristic of the western part of the state but may occur anywhere. It is still unknown in central Oklahoma.
11. Even in regions where the cannibalistic type is known to occur, some pools do not have it represented among thousands of tadpoles present. This is not thought to be due to difference in environmental factors in different pools but to genetic differences in the parents. Even in pools where the cannibalistic type occurs (either in extreme form or as intermediates) few of those present in any given pool are of this type: but where extreme modification in body size, large jaw muscles beak/notch relation in the jaws, etc. does occur among a few in a given pool, intermediates in various degrees of these characters may be expected, some of which may not show cannibalistic tendencies.

LITERATURE CITED

BALL, STANLEY C., 1936. The distribution and behavior of the spadefoot toad in Connecticut. Trans. Conn. Acad. Arts and Sci., 32: 351–379..

BRAGG, ARTHUR N., 1941. Tadpoles of *Scaphiopus bombifrons* and *Scaphiopus hammondii*. Wasmann Collector, 4(3): 72–74.

————, 1946. Aggregation with cannibalism in tadpoles of *Scaphiopus bombifrons* with some general remarks on the probably evolutionary significance of such phenomena. Herpetologica, 3: 89–96.

————, 1948. Additional instances of social aggregations in tadpoles. Wasmann Collector, 7: 65–79.

————, 1950. Observations on the ecology and natural history of Anura. XVII. Adaptations and distribution in accordance with habits in Oklahoma. Researches on the Amphibia of Oklahoma (Art. VI): 59–100, Univ. of Okla. Press, Norman.

————, 1956. Dimorphism and cannibalism in tadpoles of *Scaphiopus bombifrons* (Amphibia, Salientia). The Southwest. Nat., 1: 105–108.

GILMORE, R. J., 1924. Notes on the life history and feeding habits of the spadefoot toad of the western plains. Colorado Coll. Publ. Sci. Ser., 13(1): 1–12.

NICHOLS, RAY JANNEY, 1937. Taxonomic studies on the mouth parts of larval anura. Ill. Biol. Monographs, 25(4): 9–73.

ORTON, GRACE L., 1954. Dimorphism in larval mouth parts in spadefoots of the *Scaphiopus hammondi* group. Copeia, 1954(2): 97–100.

STEBBINS, ROBERT C., 1951. Amphibians of western North America. IX + 539 pp. University of California Press.

TURNER, FREDERICK B., 1952. The mouth parts of the tadpoles of the spadefoot toad, *Scaphiopus hammondi*. Copeia, 1952(3): 172–175.

TROWBRIDGE, MINNIE S., 1942. Studies on the normal development of *Scaphiopus bombifrons*. II. The later embryonic and larval periods. Trans. Amer. Miscro. Soc., 61: 66–83.

THE SOUTHWESTERN NATURALIST 3: 70–76 1958 (PRINTED 1959)

FEMALE REACTION TO THE MALE CALL IN TWO ANURANS (AMPHIBIA)

RALPH W. AXTELL

Department of Biology, Sul Ross State College, Alpine, Texas

All field amphibiologists know that many male anurans vocalize at different times during the year, especially, and sometimes exclusively, at the onset of a rainy season, or period of wet weather. It has been generally assumed that the call of the male anuran is a beckoning note directed toward the female of the same species so that she may locate him and reproduction be effected.

In recent years much controversy, and some field and experimental work has renewed the question: What is the primary purpose of the anuran call? A. P. Blair (1942, 1947), who has apparently been interested in whether males of a certain anuran species are attracted by the calls of males of like species, found after experimentation with *Scaphiopus couchi* in Coahuila, Mexico, that the males of this species did not necessarily go to areas where other *couchi* were calling. After making these observations, Blair (1947:67) concluded: "It has not been experimentally demonstrated that anurans respond preferentially to calls of their own species."

Lowe (1954) criticized Blair for his all inclusive and little qualified statement (above) by writing: "In view of the considerable body of such data [apparently meaning data on preferential response by a species of anuran to its own species] and the presence of no experimental evidence to the contrary, it would be of more interest to demonstrate, if possible, that anurans do not respond preferentially to the calls of their own species and that the probability indicated in such field data is therefore meaningless." The considerable body of data that Lowe refers to above is presumably not in published form, for he did not cite source material.

A more recent contribution by Bogert (1958), summarizes much of the past work on the significance of the anuran voice. He cites several examples of cases where female anurans showed visible response to sound and other sensory cues when males of their own species were involved, and he expands our knowledge regarding the call of the male and its effects on other males within audible distance.

If there is discrimination by either the male, or more importantly the female, with regard to the call of its own species, then the call should be considered an important isolating mechanism in speciation. This was adequately pointed out by W. F. Blair (1955). Bogert (loc. cit.) however, cautiously comments that Blair's beliefs rest only on field observations and that tentatively he is "forced to conclude that there is no adequate evidence to prove that voice differences are of importance as isolating mechanisms, even though field observations strongly suggest that they are for some species." It is interesting to note that Bogert presents about six paragraphs of experimental and observational findings that all tend to support the premise that the call is, or may be an important isolating mechanism, and hardly any information to the contrary.

References dealing with call discrimination in anurans are not numerous. The following works have been included and discussed in papers by the authors cited above (Noble, 1923; Goldsmith, 1926; Noble, 1941; Savage, 1935; Noble and Aronson, 1942; Bragg, 1945; and Bogert, 1947). Most of these authors were interested in other phases of anuran biology at the time of their studies, and male voice discrimination by the female was treated only incidentally.

Some years ago, I was fortunate enough to be able to observe, during daylight hours, an assembling aggregation of anuran amphibians in southern Texas. This report deals with the observations and experiments conducted at that time, and with subsequent observations at a different locality. Meager as these are, I think that they will throw additional light on the subjects discussed above.

On the afternoon of August 24, 1953, a large chorus of amphibians was heard seven miles east of Riviera, Kleberg County, Texas. Heavy rains of approximately two inches had fallen during the early afternoon and many anurans were converging toward this breeding site. When the chorus was first heard, the site was over 100 yards from me, and the sound emanating from the congregation was loud and heterogeneous so that specific calls were difficult or impossible to distinguish. The site proved to be a shallow, rounded depression with about 12 inches of rainwater in its deepest part. The pool was approximately 50 x 75 feet in dimension and was decorated around its margin with a large number of floating manure paddies. *Bufo compactilis*, *Bufo valliceps*, *Scaphiopus bombifrons*, *Scaphiopus couchi* and *Pseudacris clarki* were calling in and about the pool. After collecting several samples of each of these species, the idea for the present study presented itself and the following experiment and observations were made. A male and female *Bufo compactilis* in amplexus were found and disengaged. The

male was then freed, and the female was carried to a position in the pond where no nearby males were calling and released. Calling males were situated on three sides of the released female at distances from eight to twenty feet. Non-calling males which were floating within two or three feet of the female did not pay the slightest attention to her. The female remained passive for several minutes, and then began to swim. No orientation in the female's movements was noted at this time. Approximately ten feet from the point of release of the female sat a fairly large calling male. The male was surrounded by five smaller non-calling males, and all were stationed on an emergent spit of dry land that was projecting out into the pool. Although this large male was more distant from the female than other calling males, he definitely had a trill with greater volume and range (according to my ear) than any of his nearby fellows. The egg-heavy female had progressed nearly three feet when she paused for a moment and suddenly changed her direction at least 160 degrees from her previous course of travel. This seemed puzzling to me until several minutes later when she did exactly the same thing, but in the opposite direction. These movements at first seemed to be erratic, but soon proved what appeared to be a method of triangulation such as is used in the artillery for pin-pointing a target. During these movements the female had been progressing toward the large calling male in a series of angular steps (see Fig. 1), the male supposedly being the apex of the triangle and the destination of the female. The female would pause each time before she changed direction. This was interpreted as a listening stop, for the longitudinal plane through her body and tympanum was then at a right angle to the male call. Employing the method of orientation described above, the female moved steadily closer to the male. No other male *B. compactilis*, many of which were swimming about the female, molested her. Perhaps if she had made body contact with one of the swimming males the situation would have been different. At any rate, when the female had approached within about two feet of the male she apparently discontinued the "triangulation" method of orientation and swam directly toward him. The male did not move, but continued trilling until the female actually touched him on the chin. At this time the five smaller male toads, which had positioned themselves around the calling male, were thrown into a state of excitement and accompanied by the large male were all trying to clasp the female at the same time. Several small males were thrown off by the female before the large male achieved a clasping position. After this the smaller toads, which were presumably using the large male as a lure, were left to their own devices as the amplexing pair swam out to deeper water.

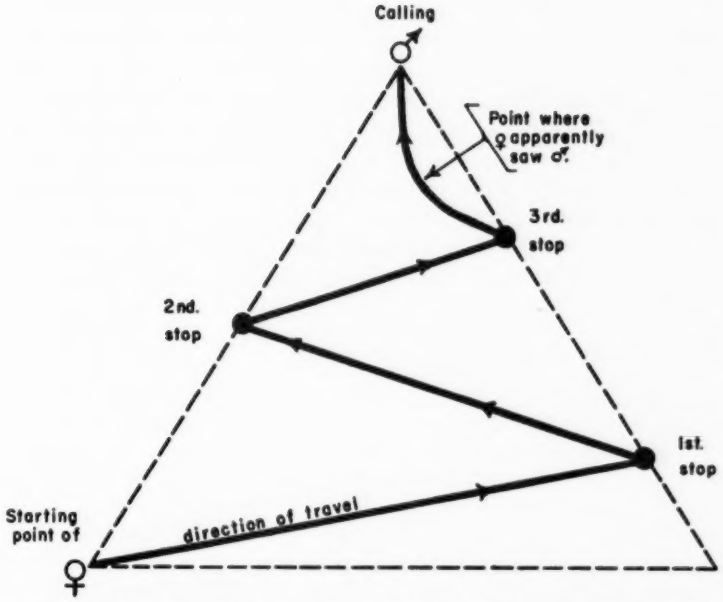


Fig. 1. Idealized diagram of the movements of a female *Bufo compactilis* toward the call of a male of the same species.

The female used in the above experiment was again separated from the male, and the same experiment repeated. The movement of the female toward another male was for all practical purposes identical with that observed in the first experiment. On this occasion however, the female appeared to be greatly aroused, and reached the calling male in less time. Another interesting event took place during the second experiment. Instead of the calling male (which had been touched by the female) obtaining the female, one of the four smaller toads, which was sitting beside the larger individual, was successful in mounting and clasping the female. She seemed very disturbed by the smaller male, and repeatedly thrashed about, apparently in an attempt to dislodge the smaller toad. The female was not successful in this attempt, and soon terminated her thrashing movements. At that time the female was placed in a collecting bag and no further observations were made.

The second opportunity to study male call affect on a female anuran presented itself on the evening of April 9, 1954, about nine miles west of Bastrop, Bastrop County, Texas. A chorus of amphibians was heard

approximately 150 yards off the highway and investigated. *Scaphiopus holbrooki*, *Bufo woodhousei*, *Hyla versicolor*, *Pseudacris streckeri*, *Gastrophryne olivacea*, and *Rana pipiens* were vocalizing in and about a rather small (25 × 50 feet) grassy depression. The water in the low area was not over six to eight inches deep and had turned brownish in color. As a considerable number of *Scaphiopus holbrooki hurteri* were present in the pool. I decided to attempt the experiment with this anuran. A male and female were found in amplexus and separated. The female was released near the edge the pond where no other *Scaphiopus* were close at hand. She quickly sank to the bottom of the pond and remained in the tangled vegetation for several minutes. During this same period most of the amphibians calling in the area had stopped (probably by the disturbance wrought by my presence). In time the female surfaced and the males in the area resumed their squalling. The female was shy, however, and it took several episodes like the one mentioned above to discover that this individual was being frightened by the concentrated light of my headlamp. I found that if I would crouch down and diffuse the light over a greater area, the female would reappear at the surface and stay there. The experiment then ran more smoothly. The female immediately began to swim toward the general region where the closest calling male was situated. She paused at intervals (supposedly to listen for the call), but each time seemed to orient herself relative to the direction from which the call came. Her reactions were rather rapid; she never paused for long periods of time, but swam steadily toward the male. The male, as in the case of *Bufo compactilis*, remained completely passive until the female touched him on the lateral part of the abdomen. The male then quickly grasped the female. This experiment was not repeated.

DISCUSSION

Although the data presented here are inconclusive and meager, several conclusions and assumptions may be made which are of importance.

1. It appears that in *Bufo compactilis* and *Scaphiopus holbrooki*, the female may choose a male of her own species. Notwithstanding chance meetings of two anurans while swimming about in the water, it seems probable that this is the usual way that the males and females of many vociferous anurans get together.

2. In the above species, the calling male was entirely passive in his relationship to the female until she approached and made body con-

tact with him. This is noteworthy, since various authors have reported that males of other anuran species actively swim around "looking for the females."

3. In the *B. compactilis* experiment above, the female showed definite signs that she was actually choosing a certain male (which happened to be both the loudest calling and the largest male in the vicinity) for she by-passed several smaller calling males on her way to the large toad. The female appeared to be actually distressed when later clasped by a smaller male toad. She shook vigorously from side to side when the smaller toad mounted her.

4. *Bufo compactilis* females presumably rely on hearing to orient themselves toward the direction of the male call. This suggests that sight in this toad may not be acute at distances over two or three feet. This may also be true with *Scaphiopus*, but here the mechanism of orientation was not clear.

5. Female *Bufo compactilis* seem to employ a certain method to guide their progress toward the call of the male. This method is compared to the triangulation system used to direct artillery fire to a target.

6. Small male *Bufo compactilis* which have not yet developed adequate vocalizing talents, may at certain times use a larger vocal male to attract a female, and be able to successfully reproduce with that female if he is not rejected by her. This might insure survival of the species in cases where fully adult males are for some reason scarce in the population.

7. If point number one above is considered significant, then two closely related species of anurans may breed in the same pool without great danger of hybridization, so long as their calls are sufficently different to prevent confusion in the females of the respective species.

As I see it, males of one species would not necessarily have to go to ponds where other males of their own species were calling. Since a female would probably go to ponds containing a greater aggregation of their own males, however, it would be of advantage to the species to concentrate where the reproductive potential would be at its highest level.

8. In particularly large choruses of anurans it might not be possible for either sex to distinguish calls of its own particular species until fairly close to the focal point of the chorus. Thus, in a large chorus, an anuran might be moving toward the chorus per se, and not toward the calls of its own species.

LITERATURE CITED

BLAIR, A. P. 1942. Isolating mechanisms in a complex of four species of toads. Biol. Sympos. 6: 235–249.

———— 1947. Field observations on spadefoot toads. Copeia. 6: 67.

BLAIR, W. F. 1955. Mating call and stage of speciation in the *Microhyla olivacea—M. carolinensis* complex. Evolution. 9: 469–480.

BOGERT, C. M. 1947. A field study of homing in the Carolina toad. Amer. Mus. Novitates. 1955: 1–24.

———— 1958. The biological significance of voice in frogs. Folkways Records Album. FX 6166: 1–17.

BRAGG, A. N. 1945. The spadefoot toads in Oklahoma with a summary of our knowledge of the group. Amer. Nat. 79: 52–72.

GOLDSMITH, G. W. 1926. Habits and reactions of *Scaphiopus hammondi*. Year Book Carnegie Inst. Wash. 25: 369–370.

LOWE, CHARLES H., JR. 1954. Isolating mechanisms in sympatric populations of southwestern anurans. Tex. Jour. Sci. 6: 265–270.

NOBLE, G. KINGSLEY. 1923. Voice as a factor in the mating of batrachians. Sci. N. S. 58: 270–271.

———— 1931. The biology of the amphibia. McGraw-Hill Book Co., New York and London. 1–577.

———— and LESTER R. ARONSON. 1942. The sexual behavior of Anura. 1. The normal mating pattern of *Rana pipiens*. Bull. Amer. Mus. Nat. Hist. 80: 127–142.

SAVAGE, R. MAXWELL. 1953. The influence of external factors on the spawning date and migration of the common frog, *Rana temporaria temporaria* Linn. Proc. Zool. Soc. London. 49–98.

THE SOUTHWESTERN NATURALIST 3: 77–89 1958 (PRINTED 1959)

CALL STRUCTURE AND SPECIES GROUPS IN U. S. TREEFROGS *(HYLA)*[1]

W. FRANK BLAIR

Department of Zoology, The University of Texas, Austin

ABSTRACT. Thirteen of the 14 U.S. species of *Hyla* are arranged in species groups primarily on the basis of mating-call structure. This is used in conjunction with evidence of genetic compatibility and morphological characters. The *versicolor* group includes the species *versicolor, phaeocrypta, femoralis, arenicolor* and *baudini*. The *cinerea* group includes *cinerea, andersoni*, and *gratiosa*. The *squirella* group tentatively includes *squirella* and *regilla*. Three other species, *crucifer, ocularis*, and *septentrionalis* do not appear closely related to any of these groups. The first two of these have calls that show similarities to calls of members of the currently recognized genus *Pseudacris*.

INTRODUCTION

Structure of the mating call of anuran amphibians provides excellent clues as to evolutionary relationships at the species level. External morphological characters alone have proved generally unsatisfactory in this respect. By use of call characters, external morphology, and such evidence of genetic compatibility as is available, it is possible to arrange U. S. species of *Hyla* in species groups indicative of close phylogenetic relationships. The calls of all of the 13 species which have been analyzed among the 14 U. S. species differ from those of every other species, but basic similarities of the call characterize certain species groups.

Quantitative studies of call variations are in progress pertinent to speciational problems in various sections of the genus *Hyla*, but the present report is concerned only with qualitative comparisons of species calls and the deductions as to species relationships that can be made from these comparisons.

The methodology includes tape recording the calls in natural populations and subsequent analysis of the calls on a sound spectrograph (Sona-Graph). This analysis gives a visual representation of the call in respect to time, frequency, and modulation pattern. Individual, intrapopulational, and geographic variations in call attributable to both genetic and environmental factors are known (Blair, 1958),

[1] This work was done under National Science Foundation grants No. G-328 and G-2215.

but these have no bearing on the present comparisons of basic structure of the calls.

I am indebted to Paul Kellogg of Cornell University for making available the recording of *Hyla septentrionalis*. The recordings of *H. baudini* and *H. andersoni* were made for individuals kindly sent me by Ted Beimler of Brownsville, Texas, and Roger Conant of the Philadelphia Zoological Society, respectively. The *H. arborea* used in a hybridization test was donated by Andrew Starrett. Recordings of *H. crucifer* in northern Ontario were made available by Bruce Falls of the University of Toronto. Wayne McAlister assisted with the sound analyses and W. F. Pyburn with the hybridizations.

VERSICOLOR GROUP

Five of the 14 U. S. species of *Hyla* appear to form a natural group. The widest ranging of these is *H. versicolor*, which occurs over the eastern half of the United States, except peninsular Florida, and into southern Canada. The ranges of *H. phaeocrypta* and *H. femoralis* lie within the range of *H. versicolor* on the Gulf coastal plain except that *femoralis* penetrates the Florida peninsula. The fourth species, *H. arenicolor*, is western and does not contact the range of any of the other three. This species ranges from trans-Pecos Texas to southwestern Utah, western Arizona and into Mexico.[2] The fifth, *H. baudini*, ranges from southern Texas to Honduras.

Hyla versicolor and *H. phaeocrypta* appear to be more closely related to one another than to others of the group. The morphological resemblance of the smaller *H. phaeocrypta* to the larger *H. versicolor* has been pointed out by Wright and Wright (1949). The call is also indicative of relationship of these two species, although it is strongly differentiated. In both species, each individual note of the pulsed call is made up of rather complex harmonically related elements. In *H. versicolor*, there is a dominant element between two and three kc per second and variously expressed harmonics of this, and each element increases distinctly in frequency from beginning to end (Fig. 1). The call of this species varies geographically in repetition rate and duration (Blair, 1958), but the basic structure remains the same. The repetition rate averaged 48.2 pulses per second and the duration averaged 0.77 second in a sample of eight individuals from Perry County, Mississippi, in the zone of sympatry with *H. phaeocrypta* when recorded at an air temperature of 24.5° C. In the call of *H. phaeocrypta*,

[2] A California population formerly regarded as belonging to this species is being described as a distinct species by Joe Gorman, and will not be considered in the present discussion. This increases the U. S. species to 15.

each individual note consists mainly of three harmonically related elements of which the first, between two and three kc per second, is dominant and the second is also strongly expressed. These elements have a more complex form than comparable elements in the call of *H. versicolor*, for the rise in frequency is followed by a broadening of the band (Fig. 1). This broadening is most pronounced in the second harmonic. As represented by a sample of nine individuals from Perry County, Mississippi, recorded at an air temperature of 25.0°C., the average repetition rate of 9.8 pulses per second is much slower than that of *H. versicolor*, and the duration of 2.0 seconds is greater. These two species have differentiated, then, in repetition rate, in duration, and in modulation pattern, with *H. phaeocrypta* showing the more complex pattern.

Hyla femoralis and *H. arenicolor* appear to be more closely related

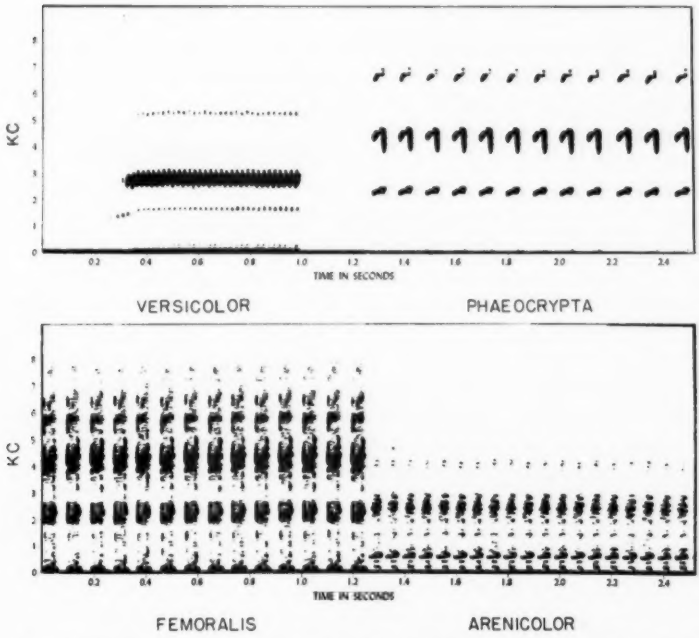


Fig. 1. Sonagrams of calls of four species of the *Hyla* versicolor group: *H. versicolor*, complete call, Perry Co., Mississippi, air temp. 24.5° C.; *H. phaeocrypta*, segment of call, Perry Co., Mississippi, air temp. 25.0° C.; *H. femoralis*, segment of call, Perry Co., Mississippi, air temp. 24.0° C.; *H. arenicolor*, segment of call, Washington Co., Utah, air temp. 14.0° C

to one another than they are to other members of the group, as judged by the call, even though there is a gap today of some 700 miles between their ranges. This distributional relationship presumably results from a Pleistocene disruption of the range of the ancestral population and the subsequent inability of either allopatric population to spread beyond its present limits. Similar distributions with similar presumed histories are known in various groups (Deevey, 1949; Blair, 1951).

In the pulsed calls of *H. femoralis* and *H. arenicolor*, each note consists of a long series of closely spaced harmonics (Fig. 1), which give the call a more noiselike character than the relatively musical calls of *H. versicolor* and *H. phaeocrypta*. The calls of both *H. femoralis* and *H. arenicolor* have a rivet-hammer quality. The call of *H. femoralis*, as represented by 3 individuals recorded in Levy County, Florida, at an air temperature of 28.0° C., has an average repetition rate of 12.0 pulses per second and an average duration of 2.6 seconds. The call of *H. arenicolor*, as represented by six individuals recorded in Washington County, Utah, at an air temperature of 16.0° C., has an average repetition rate of 15.4 pulses per second and a duration of 1.29 second. Calls of the latter species are often repeated with only a slight interval between them. The principal difference in the calls of these two species is in the emphasized frequencies. In *H. arenicolor*, the fourth harmonic at about 500 cps is emphasized and others between 1800 and 2200 cps are also emphasized but to a lesser degree. In *H. femoralis*, the second harmonic at about 200 cps and harmonically related bands at about 2600 and 4800 cps are emphasized, with the second or third of these being dominant.

The call of *H. baudini* (Fig. 4) is remarkably similar to the call of *H. femoralis* (Fig. 1) except for the greater spacing of the notes. There is an average of 3.5 notes per second in the call of an individual from Brownsville, Texas, recorded at Austin at an air temperature of 22.0° C., by comparison with 12.0 in *femoralis*. The frequency differs in that the dominant frequency in *baudini* is about 2500 cps, while in *femoralis* there is an emphasized band at about 2600 cps and another at about 4800, with one or the other dominant in different individuals.

This species ranges from extreme southern Texas south to Central America. Smith and Taylor (1948) resurrected the generic name *Smilisca* Cope for this species on the basis of the terse statement, "Peculiarities in the skull of this species, combined with the paired vocal sacs, cause us to consider this form as representative of a genus apart from *Hyla*."

A few laboratory crosses involving members of the *versicolor* group

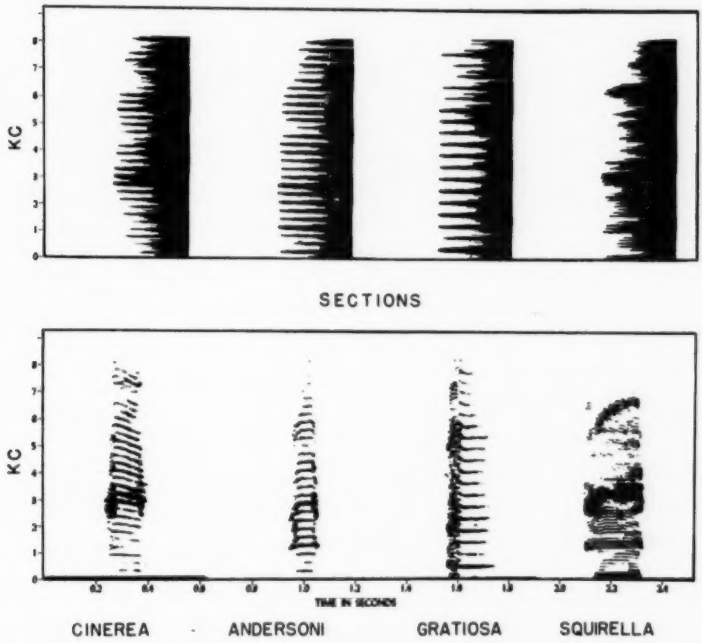


Fig. 2. Sections and sonagrams of single calls of three members of the *Hyla cinerea* group and of *H. squirella* for comparison. In sections, the length of the horizontal lines represents amplitude. *H. cinerea*, Hancock Co., Mississippi, air temp. 24.0° C.; *H. andersoni*, from Burlington Co., New Jersey, recorded at Austin, Texas, air temp. 24.0° C.; *H. gratiosa*, Perry Co., Mississippi, air temp. 25.0° C.; *H. squirella*, Perry Co., Mississippi, air temp. 24.0° C.

have been made. Limited metamorphosis was obtained from crosses between a female *H. arenicolor* from the Davis Mountains, Texas, and males of the species *femoralis*, *versicolor* and *phaeocrypta* (Table 1). Representatives of all of these crosses were nearly grown when they were lost because of faulty technique. Since no male *H. arenicolor* was available to serve as a control, the significance of the low survival through metamorphosis cannot be evaluated. Eggs fertilized by a male *H. regilla* from Fresno, California, produced abnormal zygotes in which development ceased at the yolk plug stage. A low percentage of development was noted in hybrids between a male *H. versicolor* from Polk County, Texas, and a female *H. gratiosa* from Perry County, Mississippi, and the three larvae which hatched died within three days of hatching. Moore (1955) reported that A. P. Blair found that ♀ *H.*

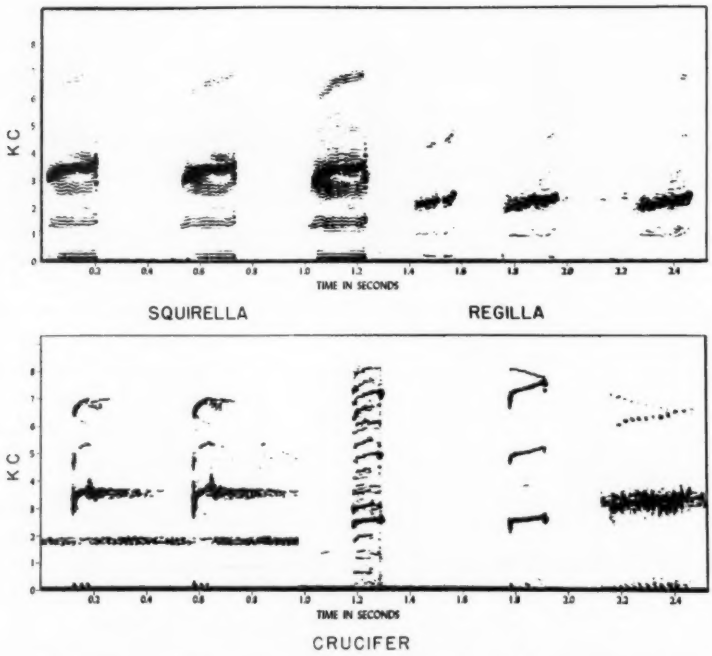


Fig. 3. Sonagrams of three calls each of two members of the *Hyla squirella* group (upper) and varied calls of *H. crucifer* (lower). *H. squirella*, Levy Co., Florida, air temp. 23.0° C.; *H. regilla*, one pulsed and two unpulsed calls, Deschutes Co., Oregon, air temp. 13.0° C. *H. crucifer*, left to right, two calls with background of *Bufo americanus* calls at 1800 and 3600 cps, Roscommon Co., Michigan, air temp. 17.0° C., opening call and typical call, Montgomery Co., Texas, air temp. 20.0° C.; pulsed call, Algonquin Park, Ontario, air temp. unknown.

versicolor × ♂ *H. crucifer* hybrids reached the larval stage and that ♀ *H. versicolor* × ♂ *H. gratiosa* hybrids metamorphosed.

The only cross between *H. baudini* and any other U. S. hylid is one between a female *H. versicolor* and a male of this species by W. F. Pyburn and J. P. Kennedy, who have given permission to quote their unpublished data. They found that 75% of 322 eggs cleaved, 10 individuals reached metamorphosis, and three survived to sexual maturity.

HYLA OCULARIS

The tiny size of this southeastern coastal plain frog makes comparison with other species difficult. The pulsed call (Fig. 4) appears to

TABLE 1

Results of crosses between a female *Hyla arenicolor* from Jeff Davis County, Texas, and males of four other species. Crosses made by stripping eggs into sperm suspensions.

♂ ♂	Number of eggs	Number cleaved	Number to tail bud	Number to muscular response	Number meta-morphosed
H. femoralis (1)					
Perry Co., Miss.	209	3	3	2	1
H. femoralis (2)					
Perry Co., Miss.	32	13	13	13	3
H. versicolor (1)					
Polk Co., Texas	163	39	39	39	14
H. versicolor (2)					
Burnet Co., Wisc.	123	110	?	81	8
H. phaeocrypta					
Perry Co., Miss.	103	17	17	17	4
H. regilla					
San Joaquin Co., Calif.	105	81	*	....	....

* Abnormal, stopped at yolk plug stage.

be more similar to the calls of the *Pseudacris nigrita* group than to those of any U. S. species of *Hyla* and suggests the possibility of relationship to that group. The very high dominant frequency (about 7,000 cps) is to be expected because of the small body size. Otherwise, the call is structurally similar to that of *Pseudacris nigrita*.

This species has been classified by various authors as a *Hyla*, as a *Pseudacris*, or in the monotypic genus *Limnaoedus* Mittleman and List. There is considerable doubt in my mind as to the justification for recognizing the genus *Pseudacris* as distinct from *Hyla*. A. P. Blair (Moore, 1955) has shown that there is greater crossability between some eastern species of *Hyla* and some referred to the nominal genus *Pseudacris* than there is between some of the species of *Hyla*.

CINEREA GROUP

Three species with unpulsed calls form a natural group on structure of the call. The most widely distributed of these is *H. cinerea*, which ranges on the coastal plain from Maryland to southern Texas. The range of *H. gratiosa* extends from the Mississippi Embayment eastward to North Carolina and lies entirely within the range of *cinerea*. The third species, *H. andersoni*, occurs in disjunct populations from New Jersey to South Carolina and is disjunct from the ranges of the

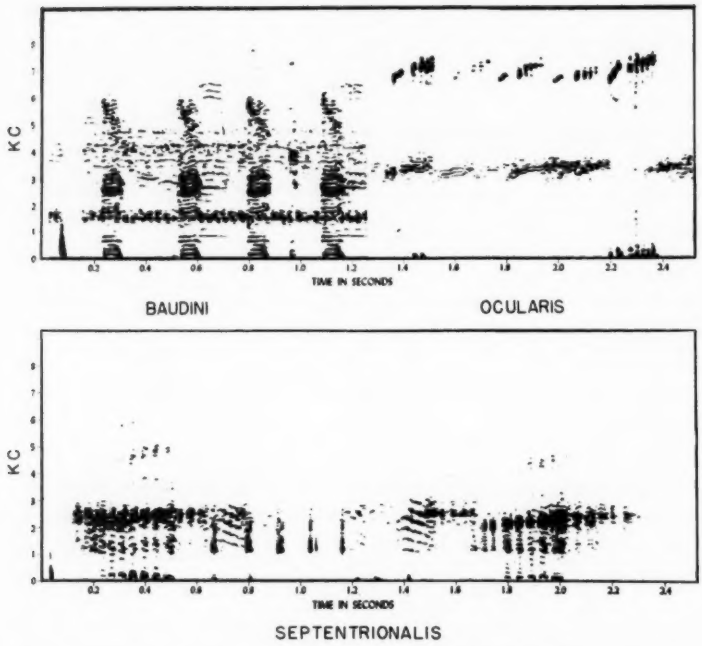


Fig. 4. Sonagrams of calls of three species. *Hyla baudini*, from Brownsville, Texas, recorded at Austin, air temp. 22.0° C., showing four pulses on background of *Bufo* and *Microhyla* calls; *H. ocularis*, with background of *H. squirella* calls between three and four Kc, Levy Co., Florida, air temp. 23.0° C.; *H. septentrionalis* from Cornell University Cut No. 47-30A-6.

other two. These three species differ from all other U. S. species in having a long series of harmonics of approximately equal intensity (Fig. 2). In two *andersoni* from Berlin, Burlington County, New Jersey, recorded at Austin, Texas, at an air temperature of 24.0° C., the number of more or less equally expressed harmonics varies from 17 to 25, with the fundamental of the series at about 350 cps. These harmonics are actually alternate ones of the harmonic series in the short initial part of the call, in which respect this species resembles *cinerea*. The chief difference between the calls of *cinerea* and *gratiosa* is that in the latter species, as represented by three individuals from Perry County, Mississippi, the third harmonic of the initial part of the call becomes the fundamental in the remainder of it, while in *cinerea*, as represented by 21 individuals from Florida, Mississippi,

and Texas, the second harmonic does so. The fundamental of the main body of the call in *gratiosa* is about 450 cps; that of *cinerea* in the sample available usually falls between 325 and 375 cps but varies from 250 to 425 cps.

Hybrids between a female *gratiosa* and male *cinerea* developed in limited numbers (Table 2), but some survived to maturity before

TABLE 2

Results of crosses between a female *Hyla gratiosa* from Perry County, Mississippi, and males of three other species. Crosses made by stripping eggs into sperm suspension.

♂ ♂	Number of eggs	Number cleaved	Number to tail bud	Number to muscular response	Number metamorphosed
H. gratiosa					
Perry Co., Miss.	181	161	154	154	5
H. cinerea (1)					
Travis Co., Texas	206	9	9	9	1
H. cinerea (2)					
Travis Co., Texas	266	?	17	17	4
H. versicolor					
Polk Co., Texas	93	?	3	3	*
H. arborea					
Italy	154	18	15	15	†

* All dead within 3 days after hatching.

† 14 dead within 3 days after hatching; the one remaining developed hind limbs and resorbed tail after thyroxine added to water 61 days after hatching, but was unable to free fore limbs and died in this stage.

being lost through faulty technique. Only three hybrids between this female and a male *versicolor* hatched, and these died soon after hatching. One individual in a cross between this female and a male *H. arborea* from Italy survived more than two months but was unable to metamorphose even when thryoxine was added to the water. A. P. Blair (Moore, 1955) reported metamorphosis of ♀ *versicolor* × ♂ *gratiosa* hybrids.

SQUIRELLA GROUP

The species *squirella* is distributed on the coastal plain from Virginia to eastern Texas. Calls of 24 individuals have been recorded in Texas, Louisiana, Mississippi and Florida. There is a long series of closely spaced harmonics with a fundamental of about 120–130 cps. A pattern of harmonically related emphasized bands with a rising

frequency is superimposed on this (Fig. 3). The rise in the superimposed bands varies considerably. The rise in the dominant band may be as much as 1200 cps (2500 to 3700 cps) or as little as 800 cps (2400 to 3200 cps). The short (about one-fourth second) call is usually repeated at intervals of about 0.20 to 0.30 second, but may have an interval of as much as 0.70 second.

Hyla regilla is one of two species of the genus on the Pacific coast, where it ranges from southern British Columbia through Baja California. It extends eastward to western Montana and eastern Nevada. The only eastern *Hyla* to which *regilla* shows any resemblance in call is *squirella*. The call of *regilla* is quite variable. Two calls were noted among six individuals recorded at Sisters, Deschutes County, Oregon, at an air temperature of 13.0° C. One of these types is structurally similar to the call of *squirella*, but has a greater concentration of energy in the dominant band (Fig. 3). The dominant band is lower than in *squirella*, and the frequency rise is less, being about 400 cps (1800 to 2200 cps). In the other type of call, the structure is the same except that each call is broken into two to four pulses. In calls having three or four pulses, the last one is more widely spaced than the preceding ones. The pulsed call has a duration of about 0.13 to 0.17 second, and the unpulsed call has one of about 0.23 second, which closely approximates the duration of the call of *squirella*. The interval between calls varies from about 0.40 to 0.73 second. The call of *regilla* therefore shows similarities to that of *squirella* in basic structure, in duration, and in interval. The two species are tentatively placed in the same group.

HYLA CRUCIFER

This species ranges over the eastern, forested United States and into southern Canada. The calls of two individuals from Texas, one from Michigan, and one from Ontario are available. Four different types of calls are represented in the recordings of these individuals (Fig. 3). The usual call is one of about 0.16 second duration and in which there are two series of widely spaced harmonics. The stronger series rises in frequency through the course of the call, while the weaker one falls. This unique situation among U. S. anurans indicates that two resonators are operating conversely. The second harmonic, which is dominant, in the rising series rises from 2300 to 2600 cps in one Texas frog and from 2900 to 3100 in the other. The call of the Ontario frog differs in having a broad band (2500 to 3100 cps) at the start of the call and then rises like the call of the Texas frogs from 3100 to 3400 cps. The

fourth harmonic is dominant in the descending series and descends at the same rate as the rise in the rising series. One of the Texas frogs which gave the call described above initiated a sequence of calls with another type in which the descending series was absent (Fig. 3). The fifth harmonic in this series, with a frequency rise from 2300 to 2400 cps, is dominant. This individual followed with a call intermediate between the two types, with the harmonics of the usual call emphasized and with traces of the descending series and then gave a sequence of typical calls. The Michigan frog, recorded at the north end of Higgins Lake, is extremely interesting. The call of about 0.10 second duration rises in a curve rather than in the straight line characteristic of the usual call of the species (Fig. 3). The harmonic pattern is the same as in the usual call, and there are traces of the descending series of harmonics. This call shows striking similarity to the calls of *Pseudacris streckeri* and *P. ornata*, from which it differs principally in the longer duration. The fourth type of call is pulsed. This call has been heard in the Texas frogs at the peak of the breeding season, but the only recording available is from Ontario. This call is sometimes interjected into a series of the usual call. As represented by the Ontario example, the duration of this call is about 0.3 second ,and the pulse rate is about 40 per second. Frequencies are the same as in the usual call, and both ascending and descending elements are evident (Fig. 3). In summary, the typical call of this species is markedly differentiated from the calls of other U. S. hylids. The call recorded for the Michigan frog resembles the calls of *P. ornata* and *P. streckeri* in structure and does not resemble the call of any U. S. *Hyla*.

A. P. Blair (1941) reported metamorphosis of ♀ *Pseudacris nigrita* × ♂ *H. crucifer* hybrids and development to gastrula or later in reciprocal hybrids. A. P. Blair (Moore, 1955) reported development to larva in a cross between a female *H. versicolor* and male *H. crucifer*. He reported development to gastrula or later in the combination of ♀ *H. crucifer* × ♂ *P. brachyphona* and in the reciprocal cross. Mecham (1957) found a lower percentage hatch of ♀ *P. streckeri* × ♂ *H. crucifer* hybrids into normal larvae than in his control. In the reciprocal cross, only three of 104 eggs cleaved, but two of these developed into normal larvae.

HYLA SEPTENTRIONALIS

This large species with a Bahamian and Cuban distribution occurs in the United States only in southern Florida, where it was possibly introduced. It does not appear to be closely related to any U. S. species.

This species shows more versatility in call than any other U. S. *Hyla* (Fig. 4). The only calls available to me are from Cornell University, Library of Natural Sounds, Cut No. 47–30A–6. A sequence of calls consisting of two structurally different sounds may be given at intervals of about 0.9 second. The first of these has a fundamental of about 300 cps and a series of harmonics up to about 5100 cps. The frequency rises and falls in a variable pattern, and the dominant frequency rises from about 2100 cps at the start to 2500 at the end. This element lasts about 0.15 second and is followed by a pulsed section about 0.30 to 0.40 second long. From five to nine pulses occur at a rate of 25 to 40 per second. The fundamental of this section is about 150 cps and has a long series of harmonics. In some sequences there is also a slowly pulsed element consisting of five pulses, each about 0.03 second in length and given at a rate of about 10 per second. The fundamental is about 105 cps, and the expressed harmonics are mostly between 945 and 2560 cps.

SUMMARY AND CONCLUSIONS

On the basis of call structure, the 13 U. S. species of *Hyla* in which the voice has been studied may be arranged in three groups totaling 10 species, and three species do not fit into any group or show close relationship to any other species currently classified as *Hyla*.

The *versicolor* group is the largest, with five species, and is the most widely distributed. Three species, *versicolor*, *phaeocrypta*, and *femoralis*, are broadly sympatric in the southeastern United States. The other two have distributions allopatric to the distributions of these three. Within the group, *versicolor* and *phaeocrypta* appear to represent one dichotomy; *femoralis* and the allopatric *arenicolor* appear to represent another. The primarily Mexican species, *baudini*, is included here on the basis of structural resemblance of its call to that of *femoralis* and *arenicolor*. The ability to produce viable hybrids with *versicolor* of this group and their survival to sexual maturity is additional evidence. This is balanced against the morphological evidence of two lateral bulges of the vocal sac rather than a single central one of other U. S. *Hyla*.

The *cinerea* group is a clear-cut one of three species on the basis of call structure, and the external morphology provides no contrary evidence. The northern species, *andersoni*, with a fragmented range, appears to be the relict of a formerly more northern distribution of the population ancestral to *cinerea* and *andersoni*, presumably during

a Pleistocene interglacial stage. The third species, *gratiosa*, occurs completely within the range of *cinerea*.

Hyla squirella of the southeastern coastal plain and *H. regilla* of the far west are tentatively placed in the same group on call structure. There is no present evidence from breeding tests. If these are indeed closely related they may have been separate for a relatively long period of time.

Hyla crucifer does not fit close to any other species of *Hyla* on call structure. One type of call recorded for this species shows resemblances to the calls of *Pseudacris streckeri* and *P. ornata*, with which species this one shares the winter-breeding habit. The few available breeding tests between this and other hylid frogs are inconclusive in respect to level of divergence. *Hyla ocularis*, about the relationships of which there has been much confusion, has a call more like that of *Pseudacris nigrita* than like that of any *Hyla* studied. *Hyla septentrionalis* does not appear to be closely related to any other U. S. hylid. We have available no recordings of *Hyla eximia* of Arizona-New Mexico mountains nor any of the Californian population formerly confused with *H. arenicolor* that is being described by Joe Gorman.

LITERATURE CITED

BLAIR, ALBERT P. 1941. Isolating mechanisms in tree frogs. Proc. Nat. Acad. Sci. U. S. 27: 14–17.

BLAIR, W. FRANK. 1951. Interbreeding of natural populations of vertebrates. Amer. Nat. 85 (820): 9–30.

———— 1958. Mating call in the speciation of anuran amphibians. Amer. Nat. 92 (862): 27–51.

DEEVEY, EDWARD S., JR. 1949. Biogeography of the Pleistocene. Bull. Geol. Soc. Amer. 60: 1315–1416.

MECHAM, JOHN S. 1957. Some hybrid combinations between Strecker's chorus frog. *Pseudacris streckeri*, and certain related forms. Tex. Jour. Sci. 9 (3): 337–345.

MOORE, JOHN A. 1955. Abnormal combinations of nuclear and cytoplasmic systems in frogs and toads. Advances in Genetics 7: 139–182.

SMITH, HOBART M. and EDWARD H. TAYLOR. 1948. An annotated checklist and key to the amphibia of Mexico. U. S. National Museum Bull. 194: 1–118.

WRIGHT, ALBERT H. and ANNA A. WRIGHT. 1949. Handbook of Frogs and Toads of the United States and Canada. Comstock Publ. Co., Ithaca, New York. xii, 640 pp.: 76 pls., 37 maps.

THE SOUTHWESTERN NATURALIST 3: 90–93 1958 (PRINTED 1959)

SLEEPING HABITS OF THE EASTERN FENCE LIZARD, SCELOPORUS UNDULATUS HYACINTHINUS (SAURIA, IGUANIDAE)

J. P. KENNEDY

Department of Biology, University of St. Thomas, Houston, 6, Texas

ABSTRACT. Field observations on sleeping fence lizards are presented with descriptions of sleeping sites. Fence lizards are consistent in the selection of a sleeping site at least over short periods insofar as climatic conditions permit. Consistency in the selection of a sleeping site is discussed in reference to the concept of home range.

Field observations on the sleeping habits of the eastern fence lizard, *Sceloporus undulatus hyacinthinus*, were made during the study of a population on a 4.5 acre tract of land located approximately 3.6 miles west of Dallardsville, Polk County, Texas. Fence lizards were permanently marked by toe clipping and daily field identification was possible without capture by painting a number on the dorsum of the lizard with a quick-drying lacquer. This technique is similar to that of Fitch (1940) and Blair (in press).

There is apparently little available information on the sleeping habits of frequently encountered diurnal lizards. Observations on sleeping lizards are usually in regard to the comparative ease of collecting lizards at night once sleeping individuals are located. Conant (1951) collected sleeping individuals of *Sceloporus cyanogenys* and *Basiliscus vittatus* under bridges in Mexico. Hoffmeister (1951) recorded *Urosaurus ornatus* sleeping in a horizontal position on the top or middle strand of a barbed wire fence in Cochise County, Arizona and he noted that these utas were apparently "environmentally ill-adjusted." According to Cagle (1948) professional collectors might collect 500 to 1000 *Anolis carolinensis* in a single night from a few acres near New Orleans. To my knowledge there are no published observations on the natural sleeping habits of one or more marked lizards over a period of time and the following records are of interest.

FIELD OBSERVATIONS

Sleeping fence lizards were not readily located at night even during the warm summer months, but several records are available from my

field notes which have been slightly edited. All references to time are Central Standard Time.

June 7, 1956. Lizard No. 57, adult female basking on a post oak, *Quercus stellata*, at 5 P.M. About 6 P.M. No. 57 went approximately 8 feet to a woodpile located between two shortleaf pines, *Pinus echinata*. This woodpile consisted of a pile of 1 inch boards and 2 × 4 inch blocks lying across two logs about 6 inches in diameter and 4 feet long. The 1 inch boards formed a platform across the logs and supported a haphazard assortment of wooden blocks and smaller planks. On the woodpile lizard No. 57 basked openly in the evening sun until 6:10 P.M. when she went beneath a 2 × 4 block about 5 inches in length. This block was tilted up at one end so that a crevice existed between the block and the underlying board. The rays of the sun penetrated the crevice and the lizard oriented herself so that the head was directed toward the west thereby receiving the most warmth. The tip of the tail was visible on the opposite side of the block. Shortly thereafter she could not be seen and apparently had gone into the deeper portions of the woodpile. At 9 P.M. I inspected the woodpile with headlight and observed this lizard asleep in the acute angle formed by the platform of planks across the supporting logs. She was resting horizontally and apparently with her entire weight upon the uppermost surface of the log so that she was not clinging, and with one side the ventral, and a portion of her dorsal surface touching the wood.

June 9, 1956. Lizard No. 3, adult female resting on log at 6:25 P.M. At 6:45 P.M. she went to the base of a pine tree, hesitated and literally crept into the litter of pine needles, leaves, and sticks. She slept here concealed from view. Lizard No. 57 had not retired to the sleeping position but was visible on the woodpile described above. At 6:58 P.M. she went beneath the lumber and into a crevice. At 7:05 P.M. she was still in this same position. I inspected the woodpile at 7:55 P.M. and she was sleeping in the identical location and position as on June 7.

August 1, 1957, 7:30 P.M. For some time I had observed at a close distance lizard No. 16, an adult female. Shortly after I had retreated as far away as 15 feet this lizard went to a blackjack oak, *Quercus marilandica* and climbed its trunk. I then slowly approached this tree and detected the lizard resting on a small limb 11 feet 4 inches from the ground. The limb was three-fourths of an inch in diameter and almost at a right angle to the trunk. The lizard was lying horizontally on this limb and somewhat sheltered beneath a leaf of an overhead limb. The lizard's head was directed away from the main trunk along the long axis of the limb which pointed west. There were other limbs of similar

appearance below this height but No. 16 was recorded sleeping in this identical location and position on the nights of August 2–8, 11, and 12.

August 13, 1957, 8:30 P.M. Lizard 645, a male hatchling, was asleep about a foot above the ground upon a small branch of a wild plum tree. The angle of this branch was such that the lizard was clinging closely to it. The head was directed upward with the branch and thus away from the very small trunk.

During the warm summer months fence lizards were observed basking shortly before 6 A.M. One individual was still sleeping at 5:30 A.M. on August 4, 1957 but was basking on the side of a tree about 4 feet from the ground when I returned for a second observation at 5:55 A.M. Fence lizards were active until about 7 or 8 P.M. in midsummer.

DISCUSSION

It is evident from these observations that these lizards are consistent in the selection of a sleeping site, at least over short periods and when fairly stable climatic conditions permit and that they appear to sleep in the same position nightly. In the above observations the sleeping site was always in close proximity to the evening basking location, and the two locations were sometimes the same. Consistency in the selection of a sleeping site is not an unexpected conclusion in a species such as the eastern fence lizard which has a well defined home range. Temperature and the degree of concealment are probably the major factors affecting the selection of a sleeping site once a home range is established and the individual becomes familiar with the local habitat. McClellan, Mensueti, and Groves (1943) observed their captive *undulatus* sleeping in the upper portion of the cage consistently, either hanging upright, resting horizontally, or head downwards.

The selection of a sleeping site is of survival importance to the species if the animal is subject to nocturnal predation. When nocturnal temperatures render lizards and other heterotherms immobile or nearly so, they are almost totally dependent upon the protection afforded by the sleeping site. The chance of elimination of an individual heterotherm through nocturnal predation in the warmer months may be greater than that during long periods of quiescence during which the animal is usually better concealed.

LITERATURE CITED

BLAIR, W. FRANK (in press). Biology of the Rusty Lizard. University of Texas Press.

CAGLE, FRED R. 1948. A population of the carolina anole. Chicago Acad. Sci. Nat. Hist. Misc. No. 15: 1–5.

CONANT, ROGER. 1951. Collecting lizards at night under bridges. Copeia 1951: 79–80.

FITCH, HENRY S. 1940. A field study of the growth and behavior of the fence lizard. Univ. Calif. Pub. Zool. 44(2): 151–172.

HOFFMEISTER, DONALD F. 1951. A technique for collecting lined utas, *Urosaurus ornatus*. Herpetologica 7(3): 146.

McCLELLAN, W. H., R. MANSUETI and F. GROVES. 1943. The lizards of central and southern Maryland. Proc. Nat. Hist. Soc. Maryland No. 8: 1–42.

THE SOUTHWESTERN NATURALIST 3: 94–101 1958 (PRINTED 1959)

CNEMIDOPHORUS TIGRIS VARIOLOSUS, A REVIVED SUBSPECIES OF WHIPTAIL LIZARD FROM MEXICO

RICHARD G. ZWEIFEL

The American Museum of Natural History, New York 24, New York

ABSTRACT. The name *Cnemidophorus variolosus* Cope, 1892, is revived as a subspecific name for populations of the species *Cnemidophorus tigris* inhabiting extreme southern Coahuila and adjacent Durango. This southern form is distinguished from the adjacent (northern) subspecies, *C. t. marmoratus*, by a heavy accumulation of melanic pigment on the venter and also by differences in dorsal pattern. The known geographic distribution of *variolosus* is described, and that of *marmoratus* is revised.

In the region of the Chihuahuan Desert, the species *Cnemidophorus tigris* has been considered to be represented by a single subspecies, *C. t. marmoratus*, found in New Mexico, western Texas, Chihuahua, Coahuila, and eastern Durango. Over much of this broad region the lizards are relatively constant in pigmentation, but at the southern edge of the area, over a latitudinal distance of at least 150 miles, a variant color pattern population occurs that is worthy of taxonomic recognition.

I am grateful to Dr. Robert Inger, Chicago Natural History Museum (abbreviated CNHM in this paper), Dr. Charles Walker and William Duellman, University of Michigan Museum of Zoology (UMMZ), and Dr. Robert C. Stebbins, University of California Museum of Vertebrate Zoology (MVZ), who sent specimens to me on loan or facilitated my study at their respective institutions. Mr. Charles M. Bogert kindly read and criticized the manuscript.

CNEMIDOPHORUS TIGRIS VARIOLOSUS Cope

Cnemidophorus variolosus Cope, 1892: 39, type locality Parras, Coahuila; type specimen U.S.N.M. 3066.

Cnemidophorus tessellatus variolosus, Cope, 1900: 587.

Cnemidophorus melanostethus, Gadow, 1906: 372.

Cnemidophorus tessellatus tessellatus, Burt, 1931: 159.

Cnimidophorus [sic] tigris marmoratus, Smith and Taylor, 1950: 190.

DIAGNOSIS: A subspecies of *Cnemidophorus tigris* characterized by

a dorsal pattern predominately of dark and light reticulations with little or no evidence of longitudinal light lines; black chest and throat; and purplish-gray to black gular region. Most closely related to *C. t. marmoratus* which has a similar dorsal pattern but has the gular region light (white, pinkish or orange in life), usually with dark spots, and the throat and chest with some dark markings but rarely or never predominately black. *Cnemidophorus tigris aethiops* of southern Arizona and Sonora has ventral surfaces similar in color to *variolosus* but the dorsal pattern is striped and spotted, not reticulate.

Discussion: In dealing with with Cope's *variolosus*, Gadow (1906: 372) synonymized it with *C. melanostethus*, which name he used also for lizards in southern Arizona now referred, part at least, to the black-chinned form *C. t aethiops*. Populations of southern Arizona (except the extreme western part) and Sonora are similar to those of southern Coahuila in possessing black or very dark chin, throat and chest, but differ markedly in dorsal pattern—light stripes on a variously spotted or otherwise broken dark background in *aethiops*, reticulations with little or no trace of linearity in *variolosus*. An airline distance of well over 300 miles separates the known ranges of the two forms, and much of the intervening territory is of a sort (for example the Sierra Madre Occidental) where *tigris* would not be found. In his extremely conservative monograph of *Cnemidophorus*, Burt (1931: 159–160) treated *variolosus* as a synonym of *C. tessellatus tessellatus*. At the present time, two species, one with seven subspecies, are recognized among the populations that Burt reserved to the single subspecies. The similarity of dorsal pattern in *marmoratus* and *variolosus* argues for a close relationship, and the most recent workers to treat the forms considered *variolosus* as a synonym of *C. tigris marmoratus* (Smith and Taylor, 1950: 190).

With regard to the characters that distinguish it from *variolosus*, *C. tigris marmoratus* is quite constant over its range. Scales of the chest often have a black anterior edge, but the chest is rarely or never predominantly black. Black spots are often but not invariably present on the pale background of the throat and chin. I have noted in larger individuals of *marmoratus* a pinkish to orange suffusion of the chin, sometimes spreading to the chest, in specimens collected by me at such widely separated localities as Samalayuca, Chihuahua; Boquillas, Coahuila; and Cuatro Cienegas, Coahuila. I presume that the color is characteristic of the subspecies.

In adult *variolosus*, the dorsal pattern is a fine reticulum that usually includes both dorsal and lateral surfaces of the body. Rarely there is some vertical barring at the sides. The side of the body in *marmoratus*

regularly shows vertical bars, and in extreme examples continuous light and dark bars cross the dorsum. Usually, however, the mid-dorsal region is reticulate, sometimes with traces of thin dorso-lateral lines showing through the reticulum.

I have collected *C. t. variolosus* at both the western and eastern limits of the range as it is presently known, as well as from intermediate localities. Throughout this region, the chest is invariably largely black. The individual scales of the chest region usually have an ill-defined light posterior border, but the all-over effect is dark. The throat is similar to the chest in pigmentation. The gular region is dark gray to black in life, and rarely shows a very slight tendency to darker mottling. The discrete, black spots seen in many examples of *marmoratus* are not present. Dark ventral coloration is present in both sexes.

With regard to black coloration, the most extreme individuals examined by me are two collected at 41 miles (by road) north-northwest of Saltillo, Coahuila. A male 89 mm. snout-vent length has the entire chin, throat, and chest jet black. Only at the very posterior end of the abdomen are there a few scales with more light than dark pigment. The top and sides of the head and the distal two-thirds of the tail are black. A female 87 mm. snout-vent length is only slightly less dark, with dark gray rather than black chin, and brown head.

I have seen no hatchlings of *variolosus*, so cannot say whether the black coloration is developed in them. The smallest individual I have examined measures 59 mm. snout-vent length and has the black of the chest well-developed with, however, slightly wider light posterior borders to the scales than is usual in larger specimens.

Scutellation: Thirty-one specimens of *variolosus*, including specimens from all parts of the known range, have an average of 98.5 $\pm$ 1.0 scales around mid-body (excluding enlarged ventrals), range 86—109. The same count was made for two samples of *marmoratus;* Twenty-six lizards from central Coahuila in the vicinity of Cuatro Cienegas, Hermanas, and Monclova average 100.2 $\pm$ 1.1 (87—110); Fifteen specimens from Alamogordo, Otero County, New Mexico average 102.5 $\pm$ 1.8 (91—116). There are no significant differences among the populations in the number of scales around mid-body.

Numbers of femoral pores often vary from population to population in *Cnemidophorus*, but *variolosus* and *marmoratus* do not appear to differ noticeably in this respect. Thirty-one *variolosus* average 45.1 $\pm$ 0.7 (40—50); twenty-five *marmoratus* from central Coahuila average 43.6 $\pm$ 0.5 (38—48); and fifteen from Alamogordo average 45.3 $\pm$ 0.6 (40—48).

Distribution of Cnemidophorus tigris variolosus

The locality records for *variolosus* cluster about a line running almost due east from the vicinity of Lerdo, Durango and Torreón, Coahuila to a few miles north and west of Saltillo, Coahuila (fig. 1). This distribution pattern is in part a consequence of the presence of the highway that connects Torreón with Saltillo, but it appears that to the north of the line at least, *variolosus* is abruptly replaced by *marmoratus*. The evidence for this exists in the distribution of the two forms in the western part of the area in question. Typical *marmoratus* is found at Las Delicias and immediately south of that place (AMNH 67370–74 + 8 untagged specimens; CNHM 46102–05). Approximately 30 miles south-southwest of Las Delicias lies San Pedro de las Colonias. Specimens of *C. t. variolosus* have been taken 12 miles north of San Pedro (CNHM 44298) and 30 miles NE (presumably by road) of San Pedro (CNMH 46100–01). It is evident that the two forms approach each other very closely here, yet the diagnostic characteristic of ventral coloration remains true for each population. Intergradation between the two forms must take place abruptly, if it indeed occurs. The general close similarity of *variolosus* and *marmoratus*, together with the knowledge of similarly abrupt transitions between other presumed subspecies of *Cnemidophorus*, leads me to assume that the relationship is subspecific.

Cnemidophorus tigris variolosus occurs in a variety of desert habitats. In the vicinity of Matamoros, *variolosus* darts among the creosote bushes *(Larrea)* and mesquites *(Prosopis)* on the sand dunes inhabited by *Uma exsul*. Near Paila, the habitat is very rocky desert with a growth of *Yucca*, *Agave*, *Larrea*, and *Fouquieria* predominating.

Locality records (Museum numbers are cited for specimens examined): Durango: 5 km. W. Torreón, Coahuila (CNHM 10778, 10783–92); 5 mi. SW Torreón Coahuila (AMNH 77275–76). Coahuila: 10 mi. E, 6 mi. S Torreón (AMNH 77279); vicinity of Matamoros (AMNH 77258); 7 mi. E. Matamoros (AMNH 77259–63); 3.3 mi. W Zapata (UMMZ 112667–68); 12 mi. N San Pedro (CNHM 44298); 30 mi. NE San Pedro (CNHM 46100–01); 19 mi. W Paila (AMNH 77285); 3.1 mi. W Paila (UMMZ 112666); 16 mi. N, 31 mi. W Parras (AMNH 77252); 12 mi. N, 10 mi. E Parras (Chrapliwy and Fugler, 1955: 126, recorded as *marmoratus*, assigned to *variolosus* on a geographic basis); Parras (Type Locality, Cope, 1892: 39); ½ mi. S San Antonio de Jaral (near Hipólito) (MVZ 24385–86); 41 mi. (by road) NNW Saltillo (AMNH 77288–89).

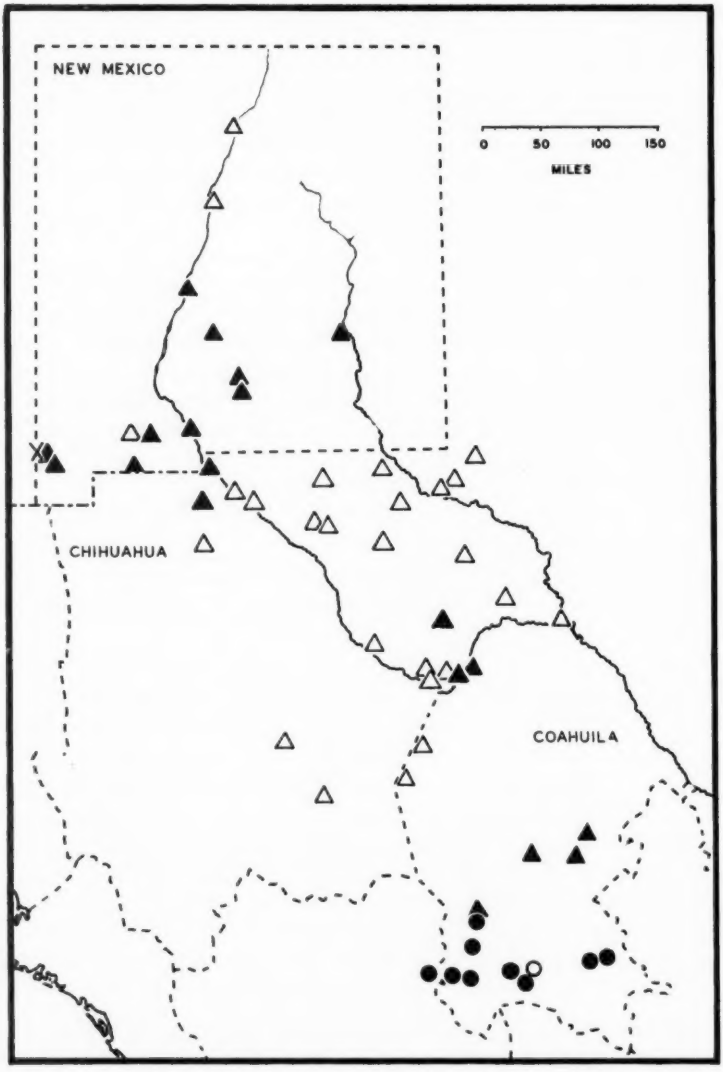


Fig. 1. Distribution of *Cnemidophorus tigris variolosus* (circles) and *C. t. marmoratus* (triangles). Closed symbols indicate localities from which specimens have been examined; open symbols indicate localities from the literature or personal communications. The X in extreme southwestern New Mexico marks two closely approximated localities for *C. tigris aethiops*.

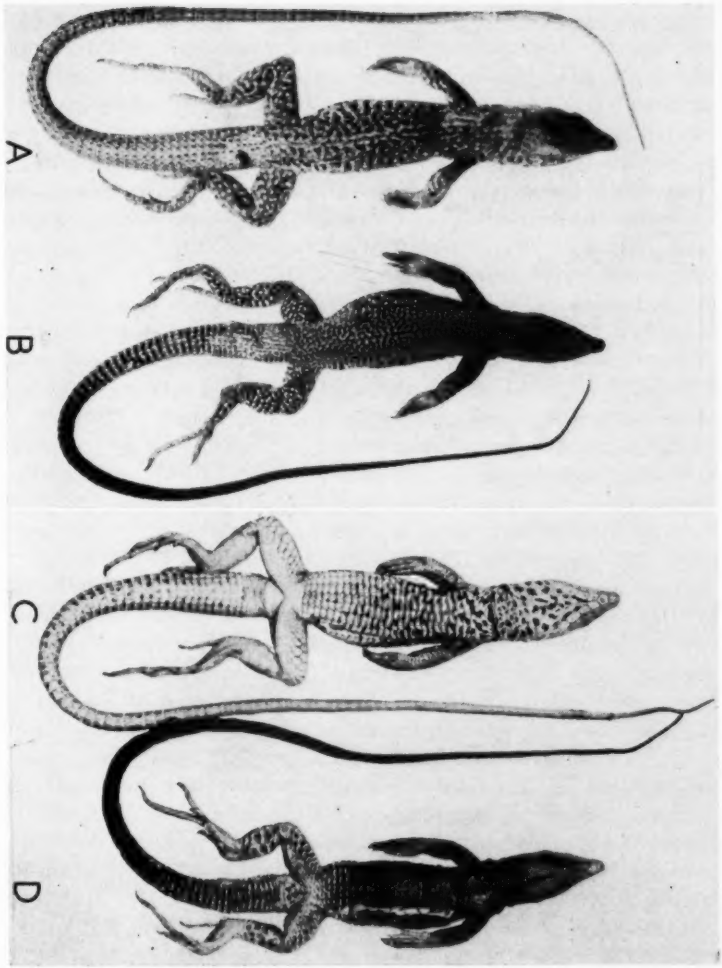


Fig. 2. A. *Cnemidophorus tigris marmoratus*, dorsal surface (AMNH 77320, Boquillas, Coahuila). B. *Cnemidophorus tigris variolosus*, dorsal surface (AMNH 77285, 19 mi. W Paila, Coahuila). C. *C. t. marmoratus*, ventral surface (AMNH 77320). D. *C. t. variolosus*, ventral surface (AMNH 77285). One-half times life size.

Distribution of Cnemidophorus tigris marmoratus

When Burger (1950: 7) revived this subspecies, that part of the range in the United States was given by him as "Southern New Mex-

ico east of the Rio Grande and Trans Pecos Texas . . ." Examination of specimens from southern New Mexico reveals that the Rio Grande does not separate two races of *tigris* in New Mexico, but typical *marmoratus* occurs almost to the western border of the state where it is abruptly replaced by *C. t. aethiops*. The dividing line between the two races seems to be the Peloncillo Mountains which parallel the Arizona-New Mexico border only a few miles to the east of that boundary. Two specimens from Granite Gap, Peloncillo Mountains, Hidalgo County, New Mexico (AMNH 73736–37) are *aethiops;* dorsal striping is distinct and the chin and chest are black. Another individual from San Simon Ciénega, Hidalgo Co. (UMMZ 114167) is also *aethiops*. An individual from 5 miles north of Animas, Hidalgo County (AMNH 73738) and two from 10 miles south of Steins, Hidalgo County (UMMZ 67307–08) are *marmoratus*. The chin is spotted with black in one specimen, immaculate in the others. The chest is spotted with black in two lizards and immaculate in the other. Two specimens (one from each locality) show perhaps slightly more than the usual trace of linearity in the dorsal pattern, suggesting some genic influence from *aethiops*. However, the data are too few and too subjective to be more than suggestive. The presence of the Sonoran Desert form *aethiops* in extreme western New Mexico and its abrupt replacement by the Chihuahuan Desert form *marmoratus* to the east of the Peloncillo Mountains recalls the similarly sharp break between *marmoratus* and *variolosus* in southern Coahuila. The extension of *C. t. aethiops* into western New Mexico parallels the distribution of some other Sonoran Desert species of reptiles discussed by Lowe (1955).

The exact distribution of *C. t. marmoratus* in New Mexico remains to be worked out. The northernmost specimens I have examined were from the vicinity of Socorro, Socorro County, near the center of the State (UCLA collection). However, there are literature records that possibly pertain to this form from Albuquerque, Bernalillo County, and Española, Rio Arriba County (Van Denburgh, 1924: 213). Possibly the range of *marmoratus* is not in contact with that of the Colorado Plateau form *C. t. septentrionalis* Burger which occurs in northwestern New Mexico. The only locality in eastern New Mexico from which I have seen specimens is 12.5 miles NW Roswell, Chaves County (UMMZ 102723, 2 specimens).

The distribution of *marmoratus* in Texas appears to be confined mostly to the Trans Pecos region, although there are a few records to the northeast of that river near the New Mexico boundary. Locality records are given by Brown (1950: 129–130) under the name *C. tessellatus tessellatus*.

There are a number of localities known for *marmoratus* in Coahuila, but few in Chihuahua. Several collectors (including the author) have obtained specimens in the dunes in the vicinity of Samalayuca, Chihuahua, near the northern border of the State. In the University of Colorado Museum collections there are specimens of *marmoratus* from 35 miles S Samalayuca and 28 miles S Chihuahua (Dr. T. Paul Maslin, personal communication). Chrapliwy and Fugler (1955: 126) reported this subspecies from localities near Camargo in southeastern Chihuahua. Probably *marmoratus* occupies most of the eastern half of Chihuahua and the northwestern corner (excluding mountainous regions) as well. In Coahuila, *marmoratus* occurs south at least to Las Delicias in the west (see discussion under *variolosus*) and Monclova on the east. There are no records for the species in extreme northeastern Coahuila, and in view of its distribution in Texas, none is to be expected.

LITERATURE CITED

BROWN, BRYCE C. 1950. An annotated check list of the reptiles and amphibians of Texas. Baylor Univ. Studies, pp. xii + 257.

BURGER, W. LESLIE. 1950. New, revived, and reallocated names for North American whiptailed lizards, genus *Cnemidophorus*. Nat. Hist. Misc., no. 65: 1–9.

BURT, CHARLES E. 1931. A study of the teiid lizards of the genus *Cnemidophorus* with special reference to their phylogenetic relationships. U. S. Natl. Mus. Bull. 154, pp. viii + 286.

CHRAPLIWY, PETE S., and CHARLES M. FUGLER. 1955. Amphibians and reptiles collected in Mexico in the summer of 1953. Herpetologica, 11: 121–128.

COPE, E. D. 1892. A synopsis of the species of the teïd [*sic*] genus *Cnemidophorus*. Trans. Amer. Philos. Soc., 17: 27–52.

————. 1900. The crocodilians, lizards, and snakes of North America. Report of the U. S. Natl. Mus. for 1898: 153–1294.

GADOW, HANS. 1906. A contribution to the study of evolution based upon the Mexican species of *Cnemidophorus*. Proc. Zool. Soc. London, 1906: 277–375.

LOWE, CHARLES H., JR. 1955. The eastern limit of the Sonoran Desert in the United States with additions to the known herpetofauna of New Mexico. Ecology, 36: 343–345.

SMITH, HOBART M., and EDWARD H. TAYLOR. 1950. An annotated checklist and key to the reptiles of Mexico exclusive of the snakes. U. S. Natl. Mus. Bull. 199; pp. v + 253.

VAN DENBURGH, JOHN. 1924. Notes on the herpetology of New Mexico, with a list of species known from that state. Proc. Calif. Acad. Sci., fourth series, 12: 189–230.

THE SOUTHWESTERN NATURALIST 3: 102–106 1958 (PRINTED 1959)

SOME OBSERVATIONS OF TEXAS CAVE BATS

GERALD G. RAUN AND JAMES K. BAKER

Department of Zoology, University of Texas, Austin 12

ABSTRACT. Several field trips to two little known caves in the Edwards Plateau of Texas have yielded some information on the habits and occurrence of three species of bats. *Mormoops megalophylla*, *Tadarida mexicana* and *Myotis velifer* were observed in association in Valdina Farms Sinkhole, Medina County. Valdina Farms Sinkhole and Webb Cave, Kinney County represent two new locality records for *Mormoops megalophylla*.

In recent years there has been an increased interest in the cave bats of Texas due to the incidence of rabies virus in these forms. This interest has been centered largely on the Mexican freetail bat, *Tadarida mexicana*, as it is in this species that the rabies virus is most frequently isolated. Present research on the Mexican free-tail, conducted by the Texas State Department of Health, by Johns Hopkins University, and by Texas Technological College, as well as by various individuals, is contributing much new information on the distribution and life habits of this and other species of bats.

Several interesting observations on some of the bat species in Texas caves made over the past several months by the authors are reported here-in and two new locality records for *Mormoops megalophylla* are also reported.

Locality records for *Mormoops megalophylla* listed previous to this are those by Eads (1956), Taylor and Davis (1947) and Mohr (1948). Eads reported *Mormoops* from Haby Cave in Medina County; Taylor and Davis report it from Brownsville in Cameron County; and Mohr lists the species from Frio Cave, Uvalde County.

The authors, several members of the University of Texas Speleological Society, and Dr. Richard B. Davis, Research Associate from Johns Hopkins University, have surveyed other caves in this region and have observed *Mormoops* from two new localities; the Valdina Farms Sinkhole and Webb Cave.

The Valdina Farms Sinkhole, located on the Valdina Farms, 16 miles north of D'Hanis, Medina County, was entered in January, February and May, 1957. A large colony of *Mormoops* was present in the cave each time. Webb Cave, Shahan Ranch, 7 miles north of

Brackettville, Kinney County, was entered in December, 1956 and again in March, 1957. A small colony was present both times.

D. K. Jameson and R. W. Mitchell observed *Mormoops* at Frio Cave in October, 1955 and in January, 1956 (Watkins, 1956). Eads (1957) indicated that Frio Cave is probably utilized as one of the winter retreats for *Mormoops*. Recent observations of *Mormoops* at the Valdina Farms Sinkhole and at Webb Cave from December through May also helps to support this evidence. The fact that they were present in May at Valdina Farms indicates that at least some of them may remain throughout the Spring as well, although in April, 1957 there were no *Mormoops* present at Frio Cave.

At Valdina Farms *Mormoops* is found in close association with *Tadarida mexicana* and *Myotis velifer*. The *Mormoops* colony is the smallest of the three. The colony of Mexican free-tails numbers in the tens of thousands, *Myotis* in the thousands and *Mormoops* only in the hundreds. On January 26, 1957 *Mormoops* was the only colony present except for a few scattered individuals of *Myotis*. A few days later however, on February 9, several hundred *Myotis* and several thousand *Tadarida* were present. This shows an early return of *Tadarida* and *Myotis* on their spring migration back into Texas. This early arrival of the *Myotis* and *Tadarida* colonies corresponds to the early 1957 arrival (first week in February) of the cave swallows at the Devil's Sinkhole, Edwards County and Webb and Frio Caves (Selander and Baker, 1957). Eads (1957) states that *Tadarida* did not usually begin their return migration until late February. In May, 1957, the colonies of *Tadarida* and *Myotis* had reached their peak in population density. The *Mormoops* colony had maintained approximately its same size as was seen in January.

Local climatological data by the U.S. Department of Commerce, Weather Bureau, states that, in the Austin, Texas area, the average monthly temperature for February, 1957 was 6.8 degrees higher than normal. The first twelve days ranged from 88 degrees to 48 degrees with a mean average of 67 degrees. During the entire month there were no freezing temperatures and vegetation was growing rapidly. As Austin is on one edge of the Edwards Plateau, its climatic conditions are comparable to those of the area in which the bat caves are located. It seems likely that the increased warmth and vegetation caused an increase in the insects and was the prime factor for the early return of the bats and the swallows.

There does not appear to be any localized territorialism in these Texas cave bats, but there is an indication of varying degrees of social

stability. The *Tadarida* observed in all the caves were grouped compactly in one or more large clusters spreading over many square feet. Naturalists at the Carlsbad Caverns (personal communication) have estimated that the free-tails there cluster at about 300 individuals to the square foot. In a large bat cave such as Bracken, Comal County, or Ney Cave, Medina County, where 30,000,000 or more bats may be housed, a roosting area of 100,000 square feet would be needed. Certainly there could be no territorialism here. However, the *Myotis* do not congregate in such large numbers as the free-tails although their clusters are still compact and there may be several small clusters instead of a single large one. Members of the *Mormoops* colony roost singly, spread out over the ceiling about six inches apart. There is nc compact cluster. This greatly reduces the size of the colony in any particular cave as it takes so much room to house fewer individuals.

The three colonies of bats in Valdina Farms Sinkhole do not appear to intermingle. They all utilize the one and only entrance and of necessity pass through each others roosting chambers in their flights. However, the roosting chambers are seemingly quite distinct. *Tadarida* inhabits a large, high-vaulted chamber just interior to the twilight zone. *Mormoops* inhabits a smaller, domed, inner chamber of some 30 to 40 yards in length, 10 yards in width and 4 yards in height. This is separated from the outer *Tadarida* chamber by a narrow passageway. *Myotis* inhabits a third chamber still deeper in the cave, and is again separated from the *Mormoops* chamber. This inner chamber is somewhat wider and longer but little higher than the chamber occupied by *Mormoops*.

The May, 1957 trip into the Valdina Farms Sinkhole was made primarily to collect neotenic salamanders found in a lake just past the chamber housing *Myotis*. Consequently, the *Myotis* colony was the only one of the three which was observed closely. Most of the females were carrying young large enough to cause considerable difficulty in flying. Our lights and activities disturbed the colony causing a large amount of activity, and many of the bats in their confusion either fell to the floor or flew into us and clung to our clothing. Two immature individuals, evidently dropped by their mothers, were seen to fall into the lake and swam quite readily to the water's edge but had some difficulty in climbing up the rather smooth, steep and slippery banks. No apparent attempt was made by the females to rescue them. In one instance a female, already carrying one young, was noted to struggle on the floor with a second female, without young, for possession of a stray juvenile. The second female was driven off

and the first, now carrying two large young, crawled to the wall but was unsuccessful in her efforts to climb or fly. Most of the individuals which fell to the floor crawled upon the walls in order to take flight, but several were seen to fly directly from the floor.

It was not noted if any of the *Mormoops* or *Tadarida* were carrying young. The only specimen of *Mormoops* to be captured did not have any young attached and as the bat was lost in the difficult climp up out of the cave, there was no opportunity to determine its sex later. Neither *Mormoops* nor *Tadarida* exhibited any difficulties in flying as did *Myotis*, indicating the probability that they were not carrying any young.

Several *Mormoops* were observed circling in and out of the vertical entrance to the cave. This was in the early forenoon and prior to our entrance into the cave. The weather was cool and rainy and the bats did not leave the opening. Neither of the two smaller bats was seen here.

It seems strange that *Mormoops* does not inhabit more caves along the southern edge of the Edwards Plateau than it does. They apparently reach their northern limit on the extreme southern edge of the plateau and go no farther. Although the caves that they do inhabit (Fig. 1) are typical of the numerous *Tadarida* and *Myotis* associated caves found in other parts of the plateau, there are suitable caves of this type which are immediately available in adjacent areas but are uninhabited by *Mormoops*.

One of these, the Devil's Sinkhole, is estimated to house 8,000,000 free-tails, along with smaller colonies of *Myotis velifer*, and occasionally *Pipistrellus hesperus*. *Corynorhinus rafinesquei* has been reported from the Devil's Sinkhole (White, 1948) but has never been seen there in several trips by either of the authors. The eastern-most cave where *Corynorhinus* has been observed by the authors is Fern Cave, approximately 20 miles north of Comstock, Val Verde County. Fern Cave is another large *Tadarida* cave, not mentioned in Eads' work. In volume it is believed to be the largest cave in the state and its *Tadarida* population is of a like magnitude with the other large free-tail caves. However, there were no *Tadarida* or *Mormoops* present when the cave was visited in January, 1957 but hibernating *Corynorhinus* and *Pipistrellus* were observed. The Rucker Bat Cave near Carta Valley, Edwards County, is another large *Tadarida* cave but there were no *Mormoops* observed there in February, 1957. This cave is relatively close to Webb Cave. Ney Cave and Bracken Cave both house several million free-tails each, but *Mormoops* has never been observed in either of them. These

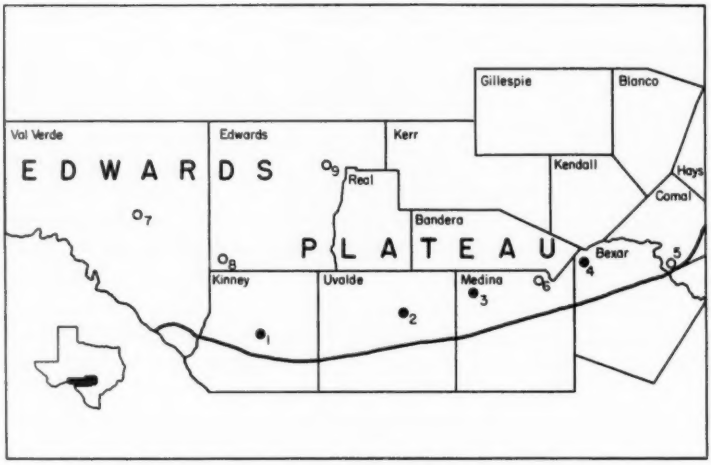


Fig. 1. BAT CAVES OF THE SOUTHERN EDWARDS PLATEAU

● Mormoops	o no Mormoops
1 Webb Cave	5 Bracken Cave
2 Frio Cave	6 Ney Cave
3 Valdina Farms Sinkhole	7 Fern Cave
4 Haby Cave	8 Rucker Cave
	9 Devil's Sinkhole

and other caves are all apparently suitable for *Mormoops* colonies, but are not utilized, possibly because some of their positions are away from the extreme southern edge of the plateau.

LITERATURE CITED

EADS, R. B., G. C. MENZIES and J. S. WISEMAN. 1956. New locality records for Texas bats. Jour. Mamm. 37 no. 3.

————, and J. S. WISEMAN. 1957. Observations concerning the Mexican free-tail bat, *Tadarida mexicana* in Texas. Tex. Jour. Sci. 9. no. 2.

MOHR, C. E. 1948. Texas cave bats. Nat. Spel. Soc. Bull. 10.

SELANDER, R. K., and J. K. BAKER. 1957. The cave swallow in Texas. The Condor 59 no. 6.

TAYLOR, W. P. and W. B. DAVIS. 1947. The mammals of Texas. Tex. Game, Fish & Oyster Comm. Bull. no. 27.

WATKINS, SUE, 1956. The old man of Frio Cave. Tex. Game & Fish, 14 no. 9.

WHITE, PATRICK J. 1948. The Devil's Sinkhole. Nat. Spel. Soc. Bull. 10.

THE SOUTHWESTERN NATURALIST 3: 107–113 1958 (PRINTED 1959)

SPATIAL ORGANIZATION IN A POPULATION OF NELSON POCKET MOUSE

KEITH L. DIXON

Department of Wildlife Management, A&M College of Texas, College Station, Texas

ABSTRACT. Results of live-trapping of *Perognathus nelsoni* on limestone slopes in the desert of southeastern Brewster County, Texas, during spring and/or early summer, 1956–1958, are presented. Individual ranges were mapped and those of females found to be complementary. Males had a similar system overlapping that of the females. Juvenal males were trapped in July at sites not frequented by adults in spring or summer. The movement of the former to optimal terrain after some resident males had disappeared suggests that the social organization of adult males influences the pattern of dispersal of juveniles.

The interest of mammalogists in devising means of measuring objectively the activity ranges of small mammals is attested by a considerable body of literature (Burt, 1943; Hayne, 1949; Blair, 1953; Stickel, 1954, and others). Included among the objectives are information on population dynamics (Blair, 1953), public health problems (Murray, 1957), and potential dispersal of seeds (Reynolds, 1954).

The study of activity ranges of nocturnal rodents is accomplished largely by inference, and certain of the limitations inherent in the methods have been reviewed by Hayne (1949) and Stickel (1954). The additional problem of seasonal differences in susceptibility to trapping (bait-acceptance) has been discussed by Stickel (1948) and Fitch (1954). These difficulties notwithstanding, live-trapping appears to be the most feasible method of study of activity ranges of nocturnal rodents. Two additional factors affecting the data collected on the Nelson pocket mouse (*Perognathus nelsoni*) in this study were the reduced activity in the winter and early spring months, and the susceptibility of the cactus mouse (*Peromyscus eremicus*) to trapping in the same habitat.

METHODS

Data were obtained by repeated live-trapping at intervals on a plot about 8 acres in extent situated on the Black Gap Wildlife Manage-

[1] Present address: Hastings Natural History Reservation, Cornel Valley, Carmel Valley (Jamesburg Route), California.

ment Area, 53 miles southeast of Marathon in Brewster County, Texas. The investigations reported here were supported by the Game and Fish Commission under a contract administered by the Texas Agricultural Experiment Station.

The trapping quadrat, situated in desert scrub vegetation at 2200 feet elevation, embraced two habitat types, (1) limestone rock slopes heavily grown to prickly pear (*Opuntia engelmanii* and *O. macrocentra*) and a leaf-succulent, *Agave lechuguilla*, and (2) gravelly flats more or less open at the ground level. The Nelson pocket mouse was virtually restricted to the former type. The 49 traps used were spaced in a grid pattern at 100-foot intervals. (Movements to a few peripheral stations were mapped, but not used in computations.) The traps were baited with grain and provided with cotton to retard chilling of trapped rodents. After March, 1957, traps were rested every second or third night in order to minimize the disruption of activity of the rodents. The animals were marked by ear-tags, and, later, by clipping of their toes. Since the assessment of population levels was the primary objective, manipulation of traps to avoid repeated capture of the same individuals was not attempted. However, the data are considered suitable for the study of movements since six adult females averaged 11.3 captures and 3.6 stations of capture, and nine males, 9.1 captures and 4.5 stations. Thus, the spacing of the traps meets Stickel's qualification (1954:13) that the traps should be arranged so that each individual can be taken in at least two traps.

Periods of trapping were as follows: 1956, February 26–28 (3 nights), March 16–21 (3 nights), June 11–July 2 (9 nights); 1957, February 21–27 (6 nights), March 20–22 (3 nights), May 10–14 (4 nights), July 15–21 (5 nights); 1958, February 22–28 (5 nights), March 24–April 1 (5 nights). Each series of trapping nights totaled in parentheses above will be designated as a trapping period in the following discussion.

RESULTS

There has been considerable debate over the procedures for measurement of "home ranges" (see Stickel, 1954:2), and no standard has met the favor of all workers. In this report the data will be presented as points of capture rather than as areas presumably occupied. A similar method of graphic presentation was used by Brown (1956:62–63), although my maps differ from his in minor respects. Because the traps were spaced widely, expression in terms of areal extent of individual ranges (especially by boundary strip methods) would lead to con-

TABLE 1

Summary of Live-trapping Records of Adult Nelson Pocket Mice

	1956		1957		1958
	Feb-March	June-July	Feb-May	July	Feb-March
Nights trapped	6	9	13	5	10
Marked individuals captured (Male)	....[1]	6	7	5	9
(Female)	....	6	5	5	3
Total captures (Male)	14	33	30	10	33
(Female)	3	30	25	8	8
Sites of capture (Male)	7	13	17	10	17
(Female)	3	12	13	6	5
(Combined Total)	8	16	23	14	21
Sites shared by both sexes	2	7	7	2	1

[1] Data incomplete because of loss of ear-tags.

clusions of doubtful validity. Hence mean recapture distance will be cited to supplement the maps.

The data presented in Table 1 give an indication of trapping intensity and rodent activity in the several trapping periods. Among the points evident are (1) reduced activity of females (fewer captures) in early spring months, (2) utilization of fewer trapsites in mid-July than in spring, (3) a small amount of overlap in use of the same traps by both sexes.

Additional indications of seasonal differences in activity may be noted in Table 2. Although more trapsites are frequented by males in spring than in summer, the mean distance of successive recapture is significantly greater in June and July. This difference is illustrated by Male 1 whose five recapture distances in the summer of 1956 averaged 320 feet, whereas three in February and March, 1957, averaged 143 feet. Mean values for the remainder of the males for these periods were 145 and 82 feet, respectively.

The ranges of females were smaller than those of males, as is indicated by the mean distance of successive recapture (Table 2), and by the fact that females made two or more visits to only 14 sites in contrast to 21 sites so visited by males.

Maps were prepared showing sites of capture of all the individual males and females for each of the calendar years. The data for 1957 are shown in Figs. 1 and 2. Records for females taken at a given trapsite were similar for each year, and in no case was more than one fe-

TABLE 2

Seasonal Differences in Activity of Adult Nelson Pocket Mice as Revealed by Live-trapping (Data for 1956–1958 are grouped)

	Feb-May	June-July
Nights trapped	29	14
Total Captures		
Male	77	43
Female	36	38
Sites of Capture		
Male	26	18
Female	17	16
Total	29	23
Mean Recapture Distance in feet		
Male	107±19	174±32
Female	74±14	58±13
Number of Recaptures		
Male	41	23
Female	28	21

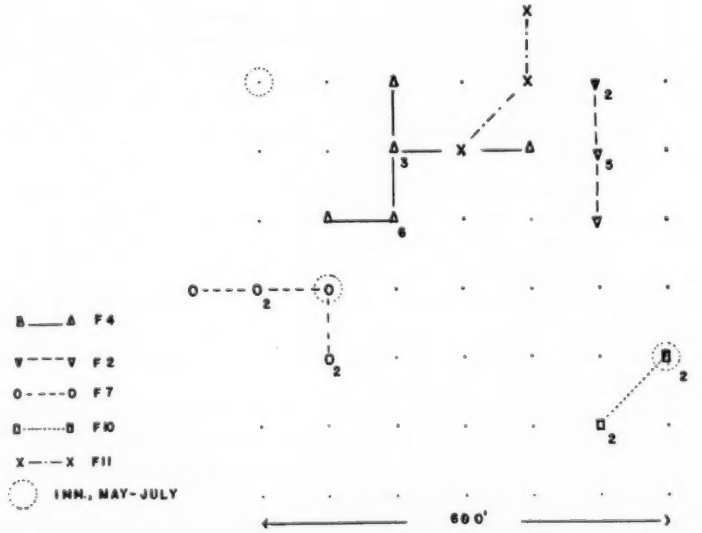


Fig. 1. Stations of capture of the five adult female Nelson pocket mice active on the 49-trap grid in the period from February through July, 1957. Large circles indicate sites of capture of three immature females in July, 1957. Numerals indicate the number of times of capture of the individual at that station.

male taken at a given trapsite. If the ranges are plotted by the inclusive boundary strip method (Blair, 1940:152), they are shown to be complementary except for single stations of capture of females whose ranges were centered elsewhere. As one might expect from the distances of successive capture, there is a tendency for the ranges of males to overlap one another. In the summer of 1956, three of 13 trapsites were shared by two males each. Two males alternated in their use of one trap on four successive nights, and the other instances of overlap represented single captures. In 1957 (February-July), two of 18 trapsites visited by male Nelson pocket mice were shared, one being used by two males and the other by four (Fig. 2). The former site was

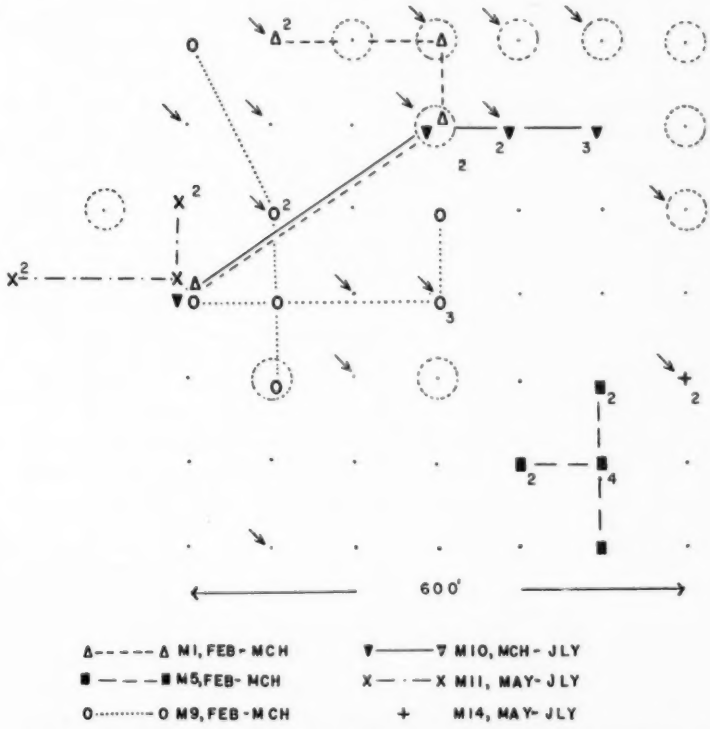


Fig. 2. Stations of capture of the six adult males taken in the period from February through July, 1957. Large circles indicate sites of capture of eight immature males in July, and arrows indicate sites of capture of the six of those males active on the plot in February and March, 1958. Numerals indicate the number of times of capture of the individual at that station.

visited by Male 10 only after Male 1 had disappeared from the record, and no more than two males shared the other trapsite in any trapping period. For Males 1 and 10 this capture represented a more distant sally than was "normal." In February and March, 1958, only two of 12 trapsites were shared.

A comparison of the maps indicates that the ranges of males and females overlapped; see Table 1 also.

Neither mutual exclusiveness nor defense of individual ranges has been demonstrated as a general population phenomenon in nocturnal rodents, although examples are known in several diurnal species of the squirrel family (see Yerger, 1953:453). Two exceptions are known to me. One is Blair's (1943:19) observation of complementary home ranges in females of the desert pocket mouse (*Perognathus penicillatus*) in April and May, but not in late March. The other is Pearson's (1953:205) report that "trap-ranges" of individual females of *Peromyscus gossypinus* did not overlap in September and October. Blair (1953:23–24) stated that there was little evidence of territoriality in heteromyid rodents, although he pointed to food storage as a probable reason why dens were not shared by individuals of *Perognathus merriami* and *Dipodomys merriami*. The mechanism by which the apparent spatial exclusiveness is maintained in *P. nelsoni* is unknown, although one might surmise a pattern of behavior similar to that reported for the little pocket mouse (*P. longimembris*) by Bartholomew and Cade (1957:70). These authors reported that captive individuals behaved aggressively toward one another and that nest chambers never were shared. Defense of nesting chamber was achieved in these captives by vocal means. A squeaking noise that apparently was an aggressive response was " . . . the first integrated response made . . . " by the pocket mouse when it was disturbed during arousal from hibernation, and Bartholomew and Cade suggest its use in the maintenance of territory.

ACTIVITY OF JUVENILES

In July, 1957, eight immature male Nelson pocket mice were trapped at 11 stations on the plot (Fig. 2), and at several stations beyond its confines as well. Seven of the 11 sites of capture of immature males were ones that were not visited by the adults that inhabited the plot regularly, and three of the sites never were visited by adults during the course of the study. Six of the eight males were taken on "suitable" sites in the following spring (Fig. 2); by this time three of the five adult males resident on the plot in May and July,

1957, had disappeared. Two of the three immature females captured in July, 1957, used sites frequented by adult females, but none of the immatures was captured subsequently. From these data it appears that the social system of the adult individuals has an important bearing on the pattern of dispersal of immatures.

LITERATURE CITED

BARTHOLOMEW, G. A. and T. J. CADE. 1957. Temperature regulation, hibernation, and aestivation in the little pocket mouse, *Perognathus longimembris*. Jour. Mammal., 38:60–72.

BLAIR, W. F. 1940. Home ranges and populations of the meadow vole in southern Michigan. Jour. Wildl. Mgt., 4:149–161.

———— 1943. Populations of the deer-mouse and associated small mammals in the mesquite association of southern New Mexico. Contr. Lab. Vert. Biol. Univ. Mich. no. 21:1–40.

———— 1953. Population dynamics of rodents and other small mammals. Advances in Genetics, 5:1–41.

BROWN, L. E. 1956. Movements of some British small mammals. Jour. Anim. Ecol., 25:54–71.

BURT, W. H. 1943. Territory and home range concepts as applied to mammals. Jour. Mammal., 24:346–352.

FITCH, H. S. 1954. Seasonal acceptance of bait by small mammals. Jour. Mammal., 35:39–47.

HAYNE, D. W. 1949. Calculation of size of home range. Jour. Mammal., 30:1–18.

MURRAY, K. F. 1957. Some problems of applied small mammal sampling in western North America. Jour. Mammal., 38:441–451.

PEARSON, P. G. 1953. A field study of Peromyscus populations in Gulf Hammock, Florida. Ecology, 34:199–207.

REYNOLDS, H. G. 1954. Some interrelations of the Merriam kangaroo rat to velvet mesquite. Jour. Range Mgt., 7:176–180.

STICKEL, L. F. 1948. Effect of bait in live-trapping Peromyscus. Jour. Wildl. Mgt., 12:211–212.

———— 1954. A comparison of certain methods of measuring ranges of small mammals. Jour. Mammal., 35:1–15.

YERGER, R. W. 1953. Home range, territoriality, and populations of the chipmunk in central New York. Jour. Mammal., 34:448–458.

THE SOUTHWESTERN NATURALIST 3: 114–123 1958 (PRINTED 1959)

SOME BRYOPHYTES FROM BAJA CALIFORNIA

HOWARD CRUM

National Museum of Canada, Ottawa, Ontario

WILLIAM C. STEERE

New York Botanical Garden, Bronx Park, New York 58

ABSTRACT. As a member of the Sefton-Stanford Expedition of 1952 to Baja California and the off-shore islands, the junior author collected a surprising number of mosses and hepatics in the extremely forbidding habitats available on Los Cedros (26 spp.), Cerralvo (6 spp.) and Partida (2 spp.) Islands and also on the mainland at Bahia de los Muertos (1 sp.). Taxonomic and distributional notes accompany the species reported, and novelties include *Aloina pilifera* (BSG) n. comb. (for *Barbula rigida* var. *pilifera* BSG) and *Crossidium seriatum* n. sp. (from Los Cedros Island). Both the latter are illustrated.

For several weeks during the spring of 1952 the junior author accompanied the Sefton-Stanford Expedition to the Gulf of California, joining the research vessel "Orca" in San Diego on March 23 and leaving her at La Paz, Baja California, on April 10 (Steere, 1953). Fortunately, this brief association with the expedition coincided with the visits of the "Orca" to those points richest in bryophytes. The first collecting station was Cedros Island, reached early on March 27. Since the major emphasis of the expedition was to be placed on the cacti and reptiles of the many islands in the Gulf of California, not much time could be spared for the study of areas along the way, and so only one day was available on Cedros Island. Nevertheless, thanks to the generous and energetic help of Dr. George Lindsay and of Dr. Reid Moran, more than 30 species of bryophytes were collected on Cedros Island, including several new to Baja California. Lindsay made his collections at the margins of water holes along the upper reaches of a deep arroyo, Moran reached the sparse forest of Bishop pines at the extreme summit of the island, and the junior author worked primarily along the edges of arroyos where fine silt had settled out in ephemeral pools and streamlets following the winter rains. In this special habitat, many mosses and hepatics had developed and flourished, and were still in excellent condition, although the silt was completely dried out and crusted into a cement. At higher levels of perhaps 1500 feet above the sea, some bryophytes were found on soil

sheltered by shrubs, on arid, highly insolated slopes. The existence of mosses in so unfavorable habitats is undoubtedly made possible by the occasional night fogs. Much further bryological work remains to be done on Cedros Island.

A brief visit to the shore at Punta San Juanico late in the afternoon of March 29 and two landings at Bahía Santa María, Isla Santa Magdalena (March 30 and 31) were completely unsuccessful from a bryologist's viewpoint. A combination of climatic and edaphic factors seems to prevent development of mosses, at least in the areas examined carefully. An exploratory visit to a large arroyo on the west side of Bahía de los Muertos, at the first stop in the Gulf of California, resulted in the discovery of a small hepatic, *Riccia violacea*. Other arroyos in the area and slopes near the end of the highway seemed quite barren of bryophytes.

Cerralvo Island, the first of the islands that the expedition had come to visit, was reached on April 2. A day and a half were spent in an exhaustive but completely unsuccessful search for bryophytes. On April 4, the "Orca" moved to a new anchorage near the mouth of a very large arroyo that heads near the center of the island. Exploration of the upper reaches of this arroyo, perhaps five miles inland, resulted in the collection of two species of hepatics and four of mosses, growing on fine silt at the edges of the arroyo and on banks and cliffs where seepage occurs after rains. The afternoon of April 5 was spent in a fruitless attempt to find bryophytes on the west slope of Espíritu Santo Island. The next day (April 6), in a deep canyon on Partida Island, on the other side of the anchorage, two mosses were found, apparently two of the same species collected on Cerralvo Island.

The "Orca" anchored at La Paz on April 7. Because the route of the expedition, as planned, would lead to progressively drier areas, and since a substantial reduction in amount and species of bryophytes was already evident, it seemed wise for the collector to call a halt to further bryological exploration in the Gulf of California, at least during the dry season. This decision turne dout to be quite sound, because although Lindsay and Moran kept up the search for bryophytes, they were able to make no further collections.

Appreciation must be expressed to Dr. George Lindsay and to Dr. Reid Moran for their expert help in collecting bryophytes, to the Sefton Foundation for generous treatment aboard the research ship "Orca" and to Prof. Ronald L. McGregor, who very kindly identified the specimens of *Riccia violacea*. A complete series of specimens re-

ported here are to be found in the Dudley Herbarium of Stanford University and the National Herbarium of Canada.

I. Los Cedros Island, March 27. Bryophytes were collected mostly on shaded silt under shrubs, or often in the shelter of other plants, at altitudes between 1000 and 2000 ft., on the east side at the north end of the island, perhaps four miles south of the point.

FRULLANIA CALIFORNICA (Aust.) Evans. High ridge among Bishop pines (*Reid Moran*), 17555.

ASTERELLA CALIFORNICA (Hampe) Underw. On silt above arroyo, 17542, 17545; in arroyo, 17546; high ridge among Bishop pines (*Reid Moran*), 17554; moist canyon (*George Lindsay*), 17559.

TARGIONIA HYPOPHYLLA L. Steep bank above arroyo, 17543; soil under shrub (*Pachycomus*), 17550; moist canyon (*George Lindsay*), 17559a. Common in Mexico and the western United States this species has also been found on Guadalupe I. (Crum & Miller, 1957).

FISSIDENS LIMBATUS Sull. On silt, edge of arroyo, 17539a. Already reported from peninsular Baja California (Koch & Crum, 1950) and Guadalupe I. (Crum & Miller, 1957).

WEISSIA CONTROVERSA Hedw. On silt, edge of arroyo, 17539 (protonematal stage with only a few very young plants which, though sterile and poorly developed, can probably be referred safely to this widespread, weedy species). Previously reported from the mainland of Baja California and also from Guadalupe I.

EUCLADIUM VERTICILLATUM (Brid.) BSG. Moist canyon (*George Lindsay*), 17560a. New to Baja California but rather common elsewhere in northern Mexico and southwestern United States in wet, calcareous habitats.

DIDYMODON TOPHACEUS (Brid.) Jur. Moist canyon (*George Lindsay*), 17560. Previously known from two collections from peninsular Baja California (Koch & Crum, 1950).

BARBULA BESCHERELLEI Jaeg. & Sauerb.? On silt, edge of arroyo, 17531 (sterile). The plants are blackened and stunted but reasonably typical in structure. *B. bescherellei* is very common in the arid highlands in Mexico and has been reported from the mainland of Baja California on the basis of four collections (Koch & Crum, 1950). Unfortunately it intergrades freely with a number of poorly delimited species, such as *B. acuta* (Brid.) Brid., and it is often impossible to assign names to sterile specimens with certainty.

BARBULA VINEALIS Brid.? On silt, edge of arroyo, 17533b, 17534e, 17538; in arroyo, 17544a; soil under shrub (*Pachycomus*), on steep ridge above 1000 ft., 17547b, 17549. *B. vinealis* is notoriously

variable, particularly in the more southern part of its western American range. These plants are very much stunted, with small, ovate, acute leaves and margins recurved nearly to the apex. Previously reported from northern Baja California (Koch & Crum, 1950).

TRICHOSTOMOPSIS BREVIFOLIA Bartr. On soil under shrub (*Pachycomus*), steep ridge above 1000 ft., 17548. This species is known from a few collections from southern California and has been reported from Arizona.

TRICHOSTOMOPSIS FAYAE Grout. On silt, edge of arroyo, 17531c, 17532b, 17533a, 17534, 17535, 17536b, 17538c (near sea); in arroyo, 17541a, 17544c; soil under shrub (*Pachycomus*), steep ridge above 1000 ft., 17549a. This species was recently described from southern California, where it has been collected a number of times, and has been collected on Guadalupe I. (Crum & Miller, 1957). It can be distinguished rather easily with a hand-lens by its blackish leaves which are twisted in a characteristic manner when dry.

POTTIA TEXANA Wareham. On silt, edge of arroyo, 17532, 17534, 17536. All the above collections were fruiting. They compare very well with the type collection. It should be noted, however, that the key in Grout's *Moss Flora* is in error. The spores of *P. texana* are not "densely and coarsely papillose," but very lightly, irregularly and finely papillose. The shortly ovoid, eperistomate capsules, slightly papillose leaf cells and especially the short-rostrate opercula serve to distinguish this species from *P. arizonica* var. *mucronulata* Wareham. Otherwise known only from a few collections in Texas; new to Mexico.

Crossidium seriatum n. sp. (Fig. 1–7). Planta pusilla, 1–2.5 mm. alta, fusca, dioica. Folia patenti-erecta, sicca imbricata, non contorta, ovata vel oblongo-ovata, abrupte pilifera, marginibus valde revolutis, lamina 0.9–1.1 mm. longa, pilus 0.7–0.86 mm. longus; costa lata, longe excurrens, superne multa fila articulata et papillosa in lamellis demissis producens; cellulae basilares subquadratae, laeves, superiores hexagonae, valde papillosae, 14–17 μ. Seta 5–9 mm. longa; capsula oblongo-cylindrica, 1.5 mm. longa, erecta; operculum longo-conicum, 0.9 mm. longum; peristomium elongatum, siccum tortum. Sporae laeves, 8–10 μ.

Very small, dull, dark-brown plants, growing scattered among other mosses on soil, 1–2.5 mm. high. Leaves erect-spreading, closely imbricate and not noticeably contorted when dry, ovate or oblong-ovate, ending in a smooth, hyaline, flexuous awn, the blade 0.9–1.1 mm. long, the awn 0.7–0.86 mm. long; margins strongly revolute from the base of the awn nearly to the base of the blade, occasionally slightly dentate

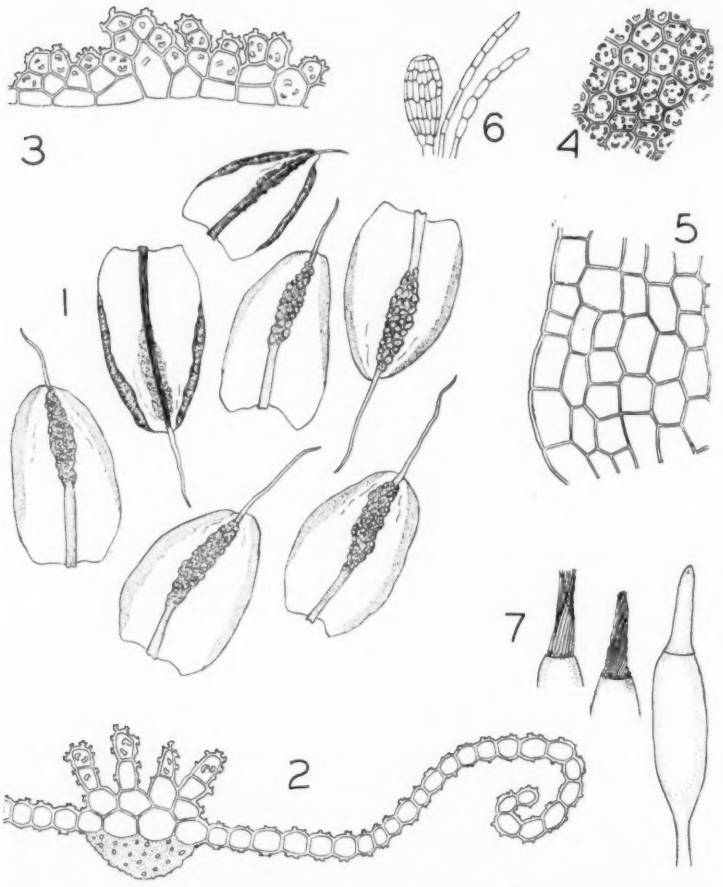


Fig. 1–7. *Crossidium seriatum*. 1. Leaves, x29. 2. Cross-section of upper portion of a leaf, x257. 3. Costal filaments, side view, showing their junction in low lamellae, x257. 4. Upper cells of leaf, x257. 5. Basal cells of leaf, x257. 6. Antheridium with paraphyses, x29. 7. Operculate capsule and peristomes, wet (left), dry (right), x16.

at the junction of blade and awn; costa long-excurrent, in section showing a large dorsal stereid band and 3–5 large guide cells covered by large cells which proliferate densely papillose, filamentous lamellae 1–4 cells high, the filaments usually 1 or 2 cells high; upper cells 14–17 μ, hexagonal, strongly papillose but not obscure, basal cells large, subquadrate, smooth. Dioicous; perichaetia and perigonia terminal,

their leaves not differentiated; perigonia with simple, filiform paraphyses. Seta 5–9 mm. long; urn of capsule 1.5 mm. long, oblong-cylindric, erect; operculum 0.9 mm. long, high-conic, bunt; annulus persistent, consisting of 2 irregular rows of small, thick-walled cells; peristome teeth about 920 μ long, consisting of 32 filiform, finely spiculose teeth joined at the base in a membrane about 125 μ high, spirally twisted when dry, nearly erect when moist; spores spherical, green, smooth, 8–10 μ.

Baja California. Cedros Island: On silt, edge of arroyo, east side at north end, perhaps 4 mi. S. of point, 1000–2000 ft. alt., March 27, 1952, *William C. Steere* 17533c (type at Stanford University, with small duplicate specimens at the National Museum of Canada and the private herbarium of E. B. Bartram), 17534f, 17535b.

This species is very nicely distinct in having its costal filaments arranged in low lamellae which are, however, usually rather difficult to demonstrate except when viewed from the side. Otherwise, *C. seriatum* greatly resembles *C. aberrans* Holz. & Bartr., but the leaf margins are strongly revolute rather than broadly reflexed, the cells are strongly papillose rather than smooth or somewhat bulging, and the filaments are more strongly roughened by larger papillae which are mostly curiously elaborated in variations of the C-shaped pattern usual in the Pottioideae.

DESMATODON CONVOLUTUS (Brid.) Grout. On silt in arroyo, 17541b; soil under shrub (*Pachycomus*), steep ridge above 1000 ft., 17547a, 17551a, 17552. Reported by Koch & Crum (1950) from northern Baja California and from Guadalupe I. and also from Guadalupe I. by Crum & Miller (1957).

Aloina pilifera (BSG) n. comb. *Barbula rigida* var. *γ. pilifera* BSG, Bryol. Eur. 2 (fasc. 13–15): "*Barbula*," p. 13. 1842. On silt, arroyo, 17533d, 17544. This species has been treated as a variety or form of *A. rigida*, both in North America and in Europe, but it seems to be perfectly distinct on the specific level. We have seen no evidence of intergradation between the blunt-leaved *A. rigida* and plants with long awns, and the two kinds of plants do not seem to grow intermingled more than occasionally. The species are very closely allied, however, and it is difficult to find any characters that would definitely distinguish them, other than the very strongly developed awns of *A. pilifera*. The essential features of the two species, as represented locally, are illustrated in figures 8–13. It should be pointed out that *A. pilifera* is inaccurately characterized in Grout's *Moss Flora;* the awns are much longer than 84 μ—actually about 1.0 mm. or more long in the Palmer collection from Guadalupe Island, cited in the *Moss Flora*,

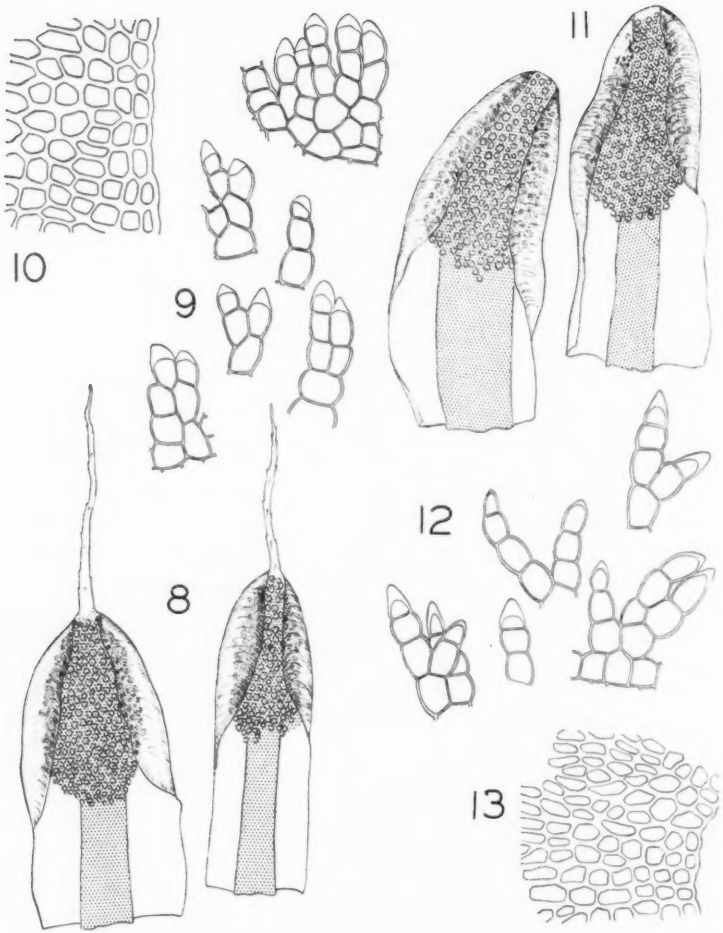


Fig. 8–10. ***Aloina pilifera.*** **8. Leaves, x29. 9. Costal filaments, x257. 10. Cells at upper leaf margin, x257. Fig. 11–13.** ***Aloina rigida.*** **11. Leaves, x29. 12. Costal filaments, x257. 13. Cells at upper leaf margin, x257.**

and in the numerous other collections which we have seen. Also known from California.

ALOINA RIGIDA (Schultz) Kindb. On silt, edge of arroyo, 17534c; on silt in arroyo, 17541. These plants seem typical in all structural features, but the leaves are somewhat shorter than usual. This differ-

ence, as well as the dark red color of the gametophytes in the local collections, may be associated with extremely xeric growth conditions. Both *Aloina* and *Aloinella* are very poorly understood in Latin America, and the numerous species should be carefully evaluated. *Aloina calceolifolia* (Spruce) Broth., a South American species, has been reported from several localities in central Mexico on the basis of plants rather similar to these. New to Mexico. The range given in Grout's *Moss Flora*—"Niagara, Illinois, Rocky Mountains, Europe"—seems very unlikely and should be confirmed.

TORTULA BREVIPES (Lesq.) Broth. On silt, edge of arroyo, 17531a, 17532a, 17533, 17534a, 17536c, 17538 (near sea); on steep bank above arroyo, 17543a; on silt in arroyo, 17544b; on soil under shrub (*Pachycomus*), steep ridge above 1000 ft., 17551. Previously known from northern Baja California (Koch & Crum, 1950) and Guadalupe I. (Crum & Miller, 1957).

TORTULA RURALIS (Hedw.) Smith. On soil under shrub (*Pachycomus*), steep ridge above 1000 ft., 17547, 17552a. Both collections are sterile and poorly developed but can probably be referred safely to this common and very widespread species which has not previously been found in Mexico in typical form, although similar forms of *T. obtusissima* (C.M.) Mitt. are common on the mainland. Depauperate material has also been found on Guadalupe I. (Crum & Miller, 1957).

GRIMMIA MONTANA BSG. Moist canyon (*George Lindsay*), 17561. The report of *G. montana* from Baja California (Koch & Crum, 1950) belongs rather to *G. alpestris* Nees (*fide* Geneva Sayre), but the species has been found on Guadalupe I. (Crum & Miller, 1957).

GRIMMIA TRICHOPHYLLA Grev. High ridge among Bishop pines (*Reid Moran*), 17555a, 17557. Seven previous collections have been cited from Guadalupe I. (Koch & Crum, 1950; Crum & Miller, 1957).

FUNARIA MUHLENBERGII Turn. On silt, edge of arroyo, 17531a, 17534g, 17537 and 17538b (near sea). Also known from the mainland of Baja California (Koch & Crum, 1950).

BRYUM ARGENTEUM Hedw. On soil under shrub (*Pachycomus*), steep ridge above 1000 ft., 17547c. Already known from Guadalupe I. as well as the mainland of Baja California (Koch & Crum, 1950).

BRYUM CAPILLARE Hedw. On silt, edge of arroyo, 17531b, 17540; high ridge among Bishop pines (*Reid Moran*), 17553a (with old sporophytes lacking capsules), 17555c, 17556. Previously collected on peninsular Baja California (Koch & Crum, 1950).

BRYUM CUSPIDATUM (BSG) Schimp.? On silt, edge of arroyo, 17532c, 17534d, 17535, 17536a. All the above collections are sterile, and in a genus such as this one only a tentative name can be chosen with any degree of certainty. New to Baja California but very widely distributed elsewhere and often weedy.

ANACOLIA MENZIESII (Turn.) Par. High ridge among Bishop pines (*Reid Moran*), 17553. This collection could perhaps be referred to the var. *baueri* (Hampe) Par., which was collected on Cedros I. by A. W. Anthony (no. 34). In the absence of capsules, however, the plants are best relegated to the species in a broad sense. Previously reported from Guadalupe I. (Koch & Crum, 1950; Crum & Miller, 1957).

ORTHOTRICHUM LYELLII var. PAPILLOSUM (Hampe) Lesq. & James. High ridge among Bishop pines (*Reid Moran*), 17555b, 17558. The species was also collected on Cedros I. by Anthony (no. 55) and reported by Koch & Crum (1950), and was also found more recently on Guadalupe I. (Crum & Miller, 1957).

II. Bahía de los Muertos, April 2. Only one species, a liverwort, was found here, some 3–4 miles south of the end of the road and the port which lies on the Gulf of California near the southern tip of Baja California.

RICCIA VIOLACEA Howe. On crusted surface of silt, under trees in a deep arroyo, 17562. R. L. McGregor, who kindly supplied the determinations for this specimen and others from Cerralvo Island, said, "The specimens were exceptionally good—much better, in fact, than any which I have previously studied. Howe described the species as being devoid of any wing on the spore. This is not quite true."

III. Cerralvo Island, April 4. Several species were found at the site of an old ranch (Rufo Ranch), at about 1000 ft. altitude, in a deep and very large arroyo on the west side of the island, about 5 miles north of the southern point. Cerralvo Island lies in the Gulf off the southern end of Baja California.

MANNIA CALIFORNICA (Gottsche) Wheeler. On soil, steep rocky bank, 17566.

RICCIA VIOLACEA Howe. On crusted surface of silt, deep, large arroyo, 17563, 17564a; on soil steep rocky bank, 17567.

WEISSIA CONTROVERSA Hedw. On granitic cliffs, in seepage channel, 17569 (sterile, but probably referable to this wide-ranging, weedy species).

HYOPHILA SINALOENSIS (Bartr.) Bartr. On steep banks and cliffs, in drainage channel, 17565. This specimen compares very well

with the type collection from Sinaloa, on the west coast of the mainland of Mexico, except that the apiculus on the leaves is rather better developed. Unfortunately no sporophytes were found, and therefore this name can only be taken as very probable but tentative.

ENTOSTHODON sp. On crusted silt, lower part of deep and very large arroyo, 17563a, 17564; on soil, steep rocky bank, 17567a, 17568 (all sterile and indeterminable).

FUNARIA MUHLENBERGII Turn.? On soil of a steep rocky bank, 17567a (sterile).

IV. Partida Island, April 6. Two collections were made on Partida Island northwest of the isthmus which runs toward Espíritu Santo I. The following species were found on silt at the base of a north-facing cliff at an altitude of about 1500 ft., at the south end of the saddle at top of a very shallow arroyo running into the bay.

HYOPHILA SINALOENSIS (Bartr.) Bartr. Sterile and largely protonematal, these plants compare well with the type and also with the specimens from Cerralvo Island cited above.

ENSTOSTHODON sp. Sterile and indeterminable.

LITERATURE CITED

CRUM, H. and H. A. MILLER. 1957. Bryophytes from Guadalupe Island, Baja California. The Southwest Nat. 1(3): 116–120. (1956).

KOCH, L. F. and H. A. CRUM. 1950. Mosses of Baja California. Rev. Bryol. et Lichénol. 19(3/4): 188–192.

STEERE, W. C. 1953. Preliminary report on the bryology of the Sefton-Stanford Expedition to the Gulf of California, 1952. Asa Gray Bull. N.S. 2: 93–95.

THE SOUTHWESTERN NATURALIST 3: 124–129 1958 (PRINTED 1959)

AN ANALYSIS OF THE GRASS VEGETATION OF TEXAS[1]

T. W. BOX AND F. W. GOULD

Texas Agricultural Experiment Station and Agricultural and Mechanical College of Texas, College Station

ABSTRACT. A comparison of the number of grass species in 10 regions of Texas and an analysis of the representation of the following 8 categories of grasses of the regions: native perennial warm-season, native perennial cool-season, native annual warm season, native annual cool season, introduced perennial warm-season, introduced perennial cool-season, introduced annual warm-season, introduced annual cool-season.

Extending some 800 miles east and west, from the Mississippi Valley to the southern Rockies, and a like distance from the southern Great Plains to the lower Rio Grande Valley, the state of Texas offers a wide variety of habitats for plant life. The rich grass flora of the state has been determined to include approximately 108 genera, 568 species, and 55 varieties other than the typical ones. Over 60 percent of the genera and over 40 percent of the species of all U. S. grasses are represented.

The following primarily is an analysis of the data presented in a recent checklist of Texas grasses (Gould, 1957). In this checklist the State was divided into ten vegetational regions: 1. Piney woods, 2. Coastal prairie, 3. Post oak savannah, 4. Blackland prairie, 5. Grand prairie, 6. Rio Grande plain, 7. Edwards plateau, 8. Rolling plains, 9. High plains, 10. Trans-Pecos. These regions are shown in Fig. 1.

In the checklist, grasses were listed for each region under the following categories: native perennial warm-season, native perennial cool-season, native annual warm-season, native annual cool-season, introduced perennial warm-season, introduced perennial cool-season, introduced annual warm-season, introduced annual cool-season.

Analysis of the data shows that of the 623 species and varieties listed in the checklist, 87 percent are native and 13 percent introduced. 77 percent are perennial and 23 percent annual, and 83 percent are warm-season grasses and 17 percent cool-season grasses.

The relative percent of native-introduced, perennial-annual, and

[1] Technical Bulletin No. T.A. 2997, Texas Agricultural Experiment Station.

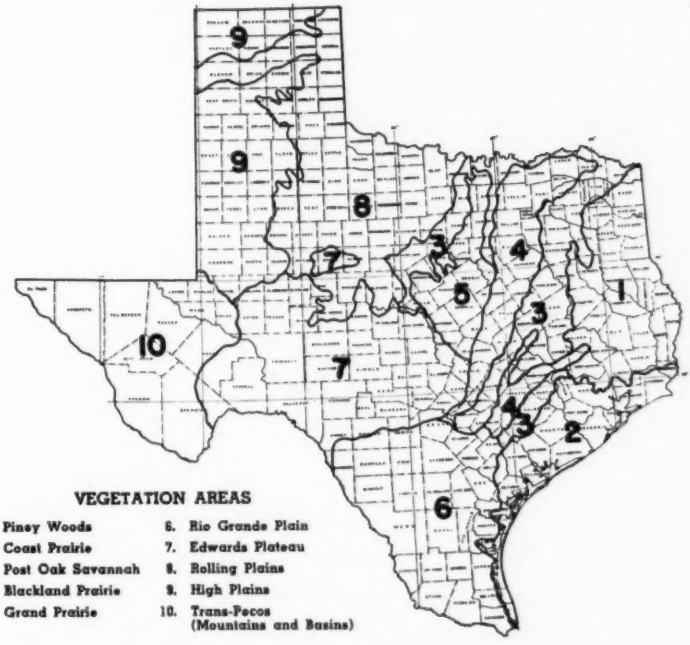


Fig. 1. The ten vegetational regions of Texas (From Gould, 1957).

warm-cool-season grasses for each region as compared with the averages for the state is shown on Table 1. Only three regions, the Blackland prairie, the Grand prairie, and the Rolling plains, differ greatly from the state average in all categories. These regions contain a greater number of introduced taxa, more annuals, and more cool-season grasses. This may be partially explained by the intensive agriculture of these regions, and the associated high number of weedy grass species.

A comparison of the number of species and varieties of all eight categories, in the ten vegetational regions, is shown on Fig. 2. It can be readily seen that in the Piney woods, Coastal prairie, Post oak savannah, and Trans-Pecos regions a relatively high number of grass species and varieties are present, while in the true prairie reigons there are relatively few species present. The combined numbers of taxa of warm-season perennials in the Blackland Prairie, the Grand Prairie, the High plains and the Rolling plains does not equal the number of taxa in either the Piney woods or the Trans-Pecos regions alone.

TABLE 1

Characteristics of the grasses in each of the ten regions of Texas as compared with the state average

	Percent native	Percent introduced	Percent perennial	Percent annual	Percent warm season	Percent cool season
State average	82	18	77	23	83	17
Piney woods	84	16	75	25	81	19
Coastal prairie	81	19	77	23	85	15
Post oak savannah	81	19	72	28	79	21
Blackland prairie	73	27	66	34	76	29
Grand prairie	79	21	67	33	77	23
Rio Grande plain	81	19	75	25	88	12
Edward's plateau	81	19	72	28	80	20
Rolling plains	79	21	70	30	79	21
High plains	85	15	73	27	83	17
Trans-Pecos	85	15	75	25	85	15

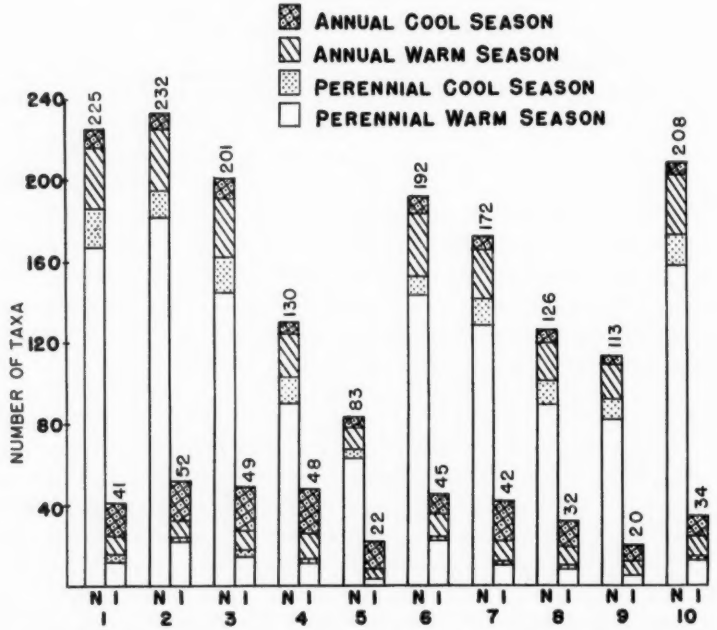


Fig. 2. Number of grass species and varieties of 8 categories in each of the 10 vegetational regions of Texas. Native (N) and introduced (I) taxa in separate columns.

The Coastal prairie, however, has a highly diverse grass flora. This can be largely accounted for by the wide variety of habitats along the dunes, beaches, brackish swamps, and sites that are actually marginal to the true Coastal prairie. The large number of taxa in the Trans-Pecos area probably is due to local differences in elevation, exposure, and moisture relations in the mountains.

The greatest difference between regions was found to be in the number of native-warm-season perennials. These grasses are dominant in all regions but the greatest number of species in this category were found in the Coastal Prairie, the Piney woods, and the Trans-Pecos regions. Little difference between the regions was found in the native-introduced, and annual-perennial categories. The Piney woods, the Post oak savannah, and Trans-Pecos regions contained above average numbers of warm-season annuals. Of the introduced grasses, the cool-season annuals were the most numerous, with warm-season perennials, warm-season annuals, and cool-season perennials following in order.

Twenty-eight grasses were found to be established in all regions of Texas. The representation of these 28 grasses in each of the 8 plant categories was as follows: native perennial warm-season, 42.0 percent; native perennial cool-season, 6.5 percent; native annual warm-season, 7.0 percent; native annual cool-season, 7.5 percent; introduced perennial warm-season, 7.0 percent; introduced perennial cool-season, 0.0 percent; introduced annual warm-season, 14.5 percent; introduced annual cool season, 10.0 percent. Fifteen taxa, or 54 percent of those successful in all regions, belonged to the subfamily Panicoideae.

With the revival of interest in the development of a more natural grass classification system, much attention has been focused on the geographical distribution and environmental adaptations of genera, tribes and subfamilies. Following the tribal concepts of Hubbard (1948) and the tribal and subfamily groupings of Stebbins (1956; see also discussion in Gould, 1958a and 1958b), the general representation of subfamilies and tribes in the Texas flora has been determined (Table 2.).

In the system of Stebbins, six subfamilies of grasses are recognized, the Bambusoideae, Phragmitoideae, Oryzoideae, Poacoideae, Eragrostoideae, and Panicoideae. The large tropical subfamily Bambusoideae is represented in Texas by a single species, *Arundinaria gigantea*. The subfamily Phragmitoideae is represented by seven genera and 21 species. The genus *Stipa* is the most important of this group, with *Stipa leucotricha*, the familiar "Texas winter-grass", an important

TABLE 2

The representation of grass subfamilies and tribes in the Texas flora. The numbers of native genera, species, and varieties (including the typical var.) listed in parenthesis in the proper column.

Subfamily	Tribe	Number of genera	Number of species	Species & varieties
Bambusoideae	Arundinareae	1 (1)	1 (1)	1 (1)
Phragmitoideae	Arundineae	2 (0)	2 (0)	2 (0)
	Danthoneae	1 (1)	2 (2)	2 (2)
	Stipeae	3 (3)	13 (13)	13 (13)
	Unioleae	1 (1)	4 (4)	4 (4)
Oryzoideae	Oryzeae	4 (3)	9 (8)	9 (8)
Poacoideae	Festuceae	15 (7)	59 (30)	63 (59)
	Meliceae	1 (1)	5 (5)	6 (6)
	Hordeae	7 (4)	17 (11)	24 (24)
	Aveneae	6 (4)	11 (8)	11 (8)
	Phalarideae	1 (1)	5 (2)	5 (2)
	Agrostoideae	6 (5)	16 (8)	16 (8)
Eragrostoideae	Pappophoreae	4 (4)	5 (5)	5 (5)
	Aristideae	1 (1)	26 (26)	27 (27)
	Eragrosteae	7 (6)	61 (54)	66 (59)
	Sporoboleae	3 (3)	58 (57)	66 (65)
	Chlorideae	14 (12)	44 (39)	44 (39)
	Hilarieae	1 (1)	4 (4)	4 (4)
	Zoysieae	1 (0)	2 (0)	2 (0)
Panicoideae	Paniceae	18 (14)	183 (156)	204 (164)
	Andropogoneae (inc. Tripsaceae)	11 (9)	41 (39)	49 (46)
	TOTALS	108 (81)	568 (472)	623 (544)

winter range forage grass throughout the state. The Oryzoideae, a relatively small subfamily of mostly marsh and aquatic grasses has four genera and nine species in the state. Of greatest economic importance is cultivated rice, *Oryza sativa* L.

Most of the Texas grasses belong to the warm temperate-tropical subfamilies Eragrostoideae and Panicoideae, and the predominately cool-temperate Poacoideae. The subfamily Panicoideae is best represented, with 29 genera and 253 species and varieties. The genus *Panicum* alone has 103 species and varieties in the state. The subfamily Eragrostoideae is represented by 31 genera and 214 species and varieties, these mostly in the tribes Eragrostideae, Sporoboleae, and Chlorideae. The genera *Muhlenbergia* and *Sporobolus* together contribute some 65 species, these predominantly in the western portion of the state.

Grasses of the Poacoideae are well distributed throughout the state, growing primarily as cool-season grasses in the southern regions and both cool- and warm-season grasses in the northwestern portion of the state. The 36 genera and 121 species of this subfamily in the Texas flora are mainly of the tribes Festuceae, Hordeae, and Agrostideae. It is noteworthy that the Poacoideae contributes 51 percent of all non-native grasses of the Texas flora, in contrast to only 16.5 percent of the native species.

SUMMARY. Analysis of the data presented in a recent checklist of Texas grasses (Gould, 1957) showed that of the 623 species and varieties listed, 77 percent were native and 23 percent introduced, 77 percent were perennial and 23 percent annual, and 83 percent were warm-season and 17 cool-season. Twenty eight grasses were found to be established in all 10 vegetative regions of the state and of these 42 percent were of the native perennial warm-season type, and 54 percent were of the Subfamily Panicoideae.

Arranged according to the subfamily-tribal concepts of Stebbins (1956), the grasses of Texas are grouped as follows in six subfamilies: Subf. Bambusoideae, one tribe, one genus, one species; Subf. Phragmitoideae, four tribes, seven genera, 21 species; Subf. Poacoideae, six tribes, 36 genera, 113 species, 125 species and varieties; Subf. Eragrostoideae, 7 tribes, 31 genera, 200 species, 214 species and varieties; Subf. Panicoideae, 2 tribes, 29 genera, 224 species, 253 species and varieties.

REFERENCES CITED

GOULD, F. W. 1957. Texas Grasses. A preliminary checklist. Texas Agric. Expt. Sta. Misc. Publ. MP-240.

————. 1958a. Range Grasses and Grasslands. Unpubl. syllabus for Range and Forestry 610 course, Texas A & M College. Typewritten.

————. 1958b. Chromosome numbers in Southwestern grasses. Amer. Jour. Bot. 45(10): 757–767.

HUBBARD, C. E. 1948. The genera of British grasses. In Hutchinson, J. British Flowering Plants. 284–348.

STEBBINS, G. L. 1956. Cytogenetics and evolution of the grass family. Amer. Jour. Bot. 43:890–905.

THE SOUTHWESTERN NATURALIST 3: 130–132 1958 (PRINTED 1959)

THREE CHROMOSOME NUMBERS FOR CLAYTONIA VIRGINICA (PORTULACACEAE)

WALTER H. LEWIS

Stephen F. Austin State College, Nacogdoches, Texas

ABSTRACT. From a restricted range in eastern Texas three chromosome numbers for *Claytonia virginica* L. are reported. Three individuals have been found with somatic numbers of 14, and one each with 15 and 28 chromosomes. No significant differences in gross morphology or pollen grain size were noted between these cytologically diverse individuals.

The somatic chromosomes of five plants of the common *Claytonia virginica* L. (spring beauty) in eastern Texas have been examined. Flower buds were pre-treated for two and a half hours in PDB (paradichlorobenzene), fixed in Carnoy's fluid (3 parts 95 per cent ethyl alcohol to 1 part glacial acetic acid), and squashed in 2 per cent acetic-orcein to obtain satisfactory mitotic plates.

Localities and collectors of the plants are listed in Table 1 and are numbered from A to E. Three plants have somatic chromosome numbers of 14, one individual has 15, and a third number of 28 is recorded for one plant (Figure 1). Note that the individual with $2n=15$ chromosomes was collected in the same population as one with 14 chromosomes. All individuals are indistinguishable by any gross morphological character.

Pollen from each of the plants having different chromosome numbers was stained in 1 per cent acetic-orcein and immediately measured across the widest diameter. Fifty pollen grains measured from each plant gave the following statistically summarized results: Plant A ($2n=14$)—$\bar{x}=63.6$ ($s=\pm 6.7$, $s\bar{x}=0.9$) u, range 43.6 − 74.4 u; Plant D ($2n=15$)—$\bar{x}=55.6$ ($s=\pm 16.7$, $s\bar{x}=2.4$) u, range 14.4 − 79.0 u; Plant E ($2n=28$)—$\bar{x}=61.9$ ($s=\pm 8.6$, $s\bar{x}=1.2$) u, range 43.9 − 79.9 u. From these data, no statistical difference can be noted in pollen size; in fact pollen from the plant with the highest chromosome number is smaller on the average than the plant with the smallest chromosome number. The aneuploid plant ($2n=15$) has the smallest average pollen size due primarily to the micro-pollen occasionally measured in the random sample (as small as 14.4 u).

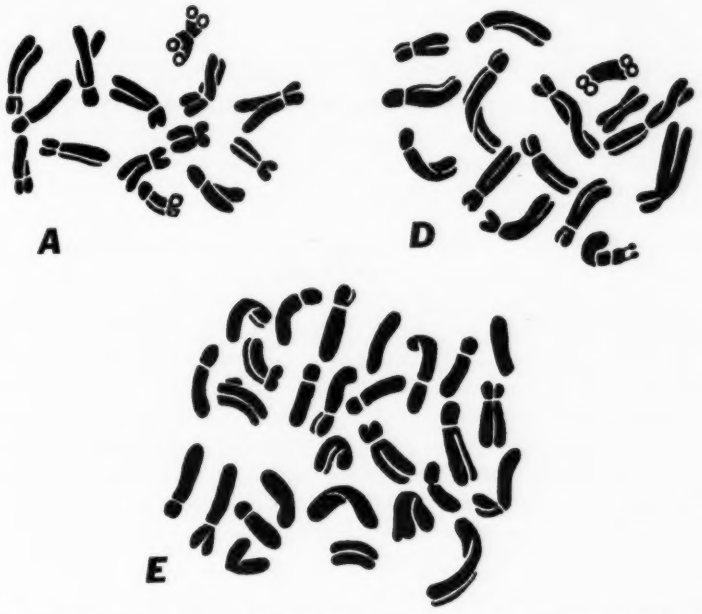


Fig. 1. Three somatic plates of *Claytonia virginica*: A—2n=14, D—2n=15, E—2n=28 (letters refer to plants recorded in Table 1); camera lucida drawing at x2350, not reduced in size.

TABLE 1

Chromosome Numbers for *Claytonia virginica*

Texas locality	Collector and date*	Somatic number
A. Nacogdoches Co.: Stephen F. Austin State College, Nacogdoches	W. H. Lewis, 5 April 1958	14
B. Nacogdoches Co.: 12 miles south of Nacogdoches	W. H. Lewis, 12 April 1958	14
C. Angelina Co.: Lufkin	J. Dies, 2 April 1958	14
D. Nacogdoches Co.: Stephen F. Austin State College, Nacogdoches	W. H. Lewis, 30 March 1958	15
E. Nacogdoches Co.: Loco Creek	J. B. Lacey, 24 March 1958	28

* All specimens are recorded in the Stephen F. Austin State College herbarium (ASTC).

In his lists of chromosome numbers, Rutland (1941) cites *C. perfoliata* Donn as 2n=36 (presumably only one plant was examined). Darlington and Wylie (1956) list *C. asarifolia* Bong. with a somatic number of 24, but repeated library research has not exposed their reference to T. Blackburn's 1937 publication. With these numbers Darlington and Wylie suggest 6 as the basic chromosome complement for the genus. Only recently brought to my attention is the work of Rothwell (1954) on *C. virginica* L. In this abstract, he describes finding "every haploid chromosome number from 6 through 18, as well as 24 and 36. . . . " To what extent each of these numbers has been found in the populations studied can only be surmised, athough Rothwell suggests the basic haploid complement of 8 for the species. This is in apparent contrast to the most common complement (yet known) of 7 for the taxon in eastern Texas.

In view of the diversity of numbers found for *C. virginica* L. and the diverse conclusions reached, one fact is certain. More individuals of *C. perfoliata* Donn and *C. asarifolia* Bong. will have to be examined, as well as the cytologically unrecorded species, before the basic haploid number of 6 or any other can be designated for the genus *Claytonia*.

LITERATURE CITED

DARLINGTON, C. D. and A. P. WYLIE. 1956. Chromosome Atlas of Flowering Plants. Macmillan Co. 519 pp.

ROTHWELL, N. V. 1954. The origin and significance of aneuploidy in *Claytonia virginica*. Dissertation Abst. *14*(8): 1135.

RUTLAND, J. P. 1941. The Merton catalogue. A list of chromosome numbers of British plants. Suppl. 1. New Phyt. *40*: 210–214.

THE SOUTHWESTERN NATURALIST 3: 133–144 1958 (PRINTED 1959)

STUDIES IN THE CAPPARIDACEAE—V.

CAPPARIDACEAE OF NEW MEXICO

HUGH H. ILTIS

Department of Botany, University of Wisconsin, Madison 6

ABSTRACT. The following taxa, all in subfamily Cleomoideae, occur in the state: *Polanisia dodecandra* (L.) DC., ssp. *dodecandra* var. *trachysperma* (T. & G.) Iltis. *P. dodecandra* ssp. *uniglandulosa* (Cav.) Iltis, *Cleome lutea* Hook., *C. serrulata* Pursh, *C. multicaulis* Sessé & Mociño, *Cleomella longipes* Torr., *Wislizenia refracta* Engelm. In addition, *Polanisia jamesii* (T. & G.) Iltis (*Cristatella jamesii* T. & G.) is to be expected, since it occurs near the New Mexico boundary in adjacent states on the northeast and southeast. Keys, synonymy, descriptions, distribution, and flowering period are given for all these taxa.

This study is based on specimens deposited at the following institutions: University of New Mexico, New Mexico College of Agriculture and Mechanic Arts, Missouri Botanical Garden, U.S. National Herbarium, and University of Wisconsin. Grateful acknowledgement is due the Wisconsin Alumni Research Foundation, which supported final phases of the work during the summer of 1957.

The following family description applies especially to New Mexican representatives, all of which are members of the subfamily Cleomoideae.

CAPPARIDACEAE

Herbs with a strong, more or less fetid or rank odor. Leaves alternate, petiolate, palmately compound, with 3 or 5 leaflets (rarely 1), entire, usually stipulate; stipules minute, setaceous. Flowers perfect or rarely by partial cyclic abortion unisexual, more or less zygomorphic, pedicellate or rarely subsessile, usually in terminal racemes, less frequently axillary and solitary or in dense axillary racemose clusters; racemes bracteate or (by reduction) ebracteate. Calyx lobes or sepals usually 4, minute and smaller than the petals; petals 4, sessile to clawed, distinct, the two posterior frequently larger; nectariferous disk between corolla and androecium frequently present; stamens 6–27, equal to the petals or usually exserted, the anthers dehiscing longitudinally; pistil 1, borne on a short or long stipe (gynophore); ovary superior, unilocular or (*Wislizenia*) falsely bilocular, carpels 2, placentation parietal, ovules few to many, campylotropous; style 1, short to filiform, stigma truncate. Fruit either a few- to many-seeded, 2-valved capsule (silique or silicle) dehiscing by separation of the valves from the slender, hoop-shaped placenta (replum), or a 2-valved schizocarp (*Wislizenia*) with valves separating from the placenta as 1- or 2-seeded, closed nutlets. Seeds reniform, with testa

deeply invaginated; embryo curved, conduplicate; endosperm scanty; seeds exarillate.

KEY TO GENERA

1. Plants usually viscid-pubescent. Stamens (8–)13–27, unequal at aestivation. Corolla open in bud. Petals whitish, pinkish (or yellowish?), notched or irregularly torn at apex, with long slender claw. Gland strictly adaxial, bright orange or yellow, concave at apex and solid, or a hollowed-out tube. Siliques erect, subsessile, dehiscing apically, the hirsute-glandular valves persistent. Cleft of seed open. .....1. *Polanisia*

1b. Plant essentially glabrous. Stamens 6, equal. Corolla closed (convolute) in bud. Petals yellow, pink, or rarely white, rounded to pointed at apex. Gland (if present) more or less concentric, though often expanded adaxially. Fruit pendent or rarely erect, usually borne on an elongate gynophore, the valves freely deciduous. Cleft of seed closed, the two claws fused for most of their length.

2a. Fruits elongate capsules (siliques) or short, round or laterally expanded capsules (silicles), unilocular, the seeds and valves falling free and separate. Racemes bracteate.

3a. Fruits many-seeded elongate capsules (siliques), 10–80 mm. long. Petals pink to purple, yellow, or white..... .....2. *Cleome*

3b. Fruits few-seeded rhomboidal capsules (silicles), 4–8 mm. long. Petals yellow. (Hidalgo Co.) ....3. *Cleomella*

2b. Fruits didymous schizocarps, with each of the 2 valves closely and permanently enclosing its single seed (rarely 2 seeds) and falling away with it, forming 2 nutlets, each 1–3 mm. long. Racemes ebracteate. .....4. *Wislizenia*

1. POLANISIA Raf., Amer. Jour. Sci. 1: 378. 1819. *Jacksonia* Raf., Med. Rept. II. 5: 352. 1808 (*Nomen nudum.*). *Cleome* sect. *Polanisia* (Raf.) Baill., Hist. Pl. 3: 149. 1872.

Erect, unarmed, slender to robust annuals, viscid-pubescent, with rank odor, simple or branched. Leaves petiolate, 3-foliolate; leaflets entire; stipules minute, or obsolete in mature parts. Racemes terminal, strongly elongating in fruit, bracteate. Corolla open in bud; sepals free to base, deciduous in fruit; petals spatulate with a long claw or obovate, emarginate to laciniate, white to pale pink (or yellowish?), the adaxial pair longer; gland between corolla and androecium prominent, strictly adaxial, either solid with concave apex or tubular and

hollow, yellow to orange-red. Stamens (6–)8–27, of unequal length because of staggered maturation. Fruit a many-seeded, elongate silique, erect, sessile or on a short gynophore; valves papery, dehiscing apically, persistent in fruit. Seeds subspherical, smooth, the cleft formed by the deep invagination of the testa narrow but open.

KEY TO SPECIES

1a. Leaflets broad, 5–20 mm. wide. Petals 8–27 mm. long, shallowly notched. Gland solid, 2–3 mm. wide and long. Style slender, 6–26 mm. long, deciduous in fruit. Siliques 5–10 mm. wide. ....1. *P. dodecandra*

1b. Leaflets linear, 1–4 mm. wide. Petals 3–4 mm. long, deeply cut. Gland a hollow tube, 2–4 mm. long, 1 mm. wide. Style 1 mm. long, persistent. Siliques 2–4 mm. wide. .....2. *P jamesii*

1. POLANISIA DODECANDRA (L.) DC., Prodr. 1: 242. 1824. Maps 1 and 2. *Cleome dodecandra* L., Sp. Pl. (ed. 1) 2: 672. 1753.

Sparsely branched annual herbs 2–7 dm. tall. Petioles 1–3 cm. long. Leaflets elliptic to oblanceolate or obovate, 1–4 cm. long, 5–20 mm. wide. Bracts reduced, subsessile, ovate. Sepals 3–8 mm. long, lanceolate, the adaxial ovate, deciduous. Petals spatulate, gradually attenuate to the slender claw, shallowly to deeply notched at apex, 8–27 mm. long, white, pinkish white (or sulfur yellow?). Gland solid, about 2–3 mm. long, over 2 mm. wide, with a concave, bright orange apex. Stamens 8–27, purple, 8–35 mm. long. Style slender, purplish, 6–26 mm. long, soft, deciduous and withering in fruit. Siliques oblong-fusiform to linear, 35–95 mm. long, 5–10 mm. wide, on pedicels 15–35 m. long. Seeds many, suborbicular, rusty to dark brown.

British Columbia to Arizona, Quebec, Missouri, and south to Chiapas (Mexico). Divisible into three infraspecific entities, two of which occur in New Mexico, the third in the northeastern U.S.

KEY TO INFRASPECIFIC TAXA

1a. Petals 7–15 mm. long, whitish or pale pinkish white. Stamens 10–20, 11–23 mm. long. Seeds wrinkled on back, or at least dull. Northern half of state. ....1a. *P. d.* ssp. *dodecandra* var. *trachysperma*

1b. Petals 14–25 mm. long, whitish (or sulfur yellow?). Stamens (15–) 20–27, 19–31 mm. long. Seeds sooth, somewhat shiny, often with a coppery sheen. Southwestern quarter of state. ....1b. *P. d.* ssp. *uniglandulosa*

1a. POLANISIA DODECANDRA ssp. DODECANDRA var. TRACHYSPERMA (T. & G.) Iltis, Brittonia 10: 44. 1958. Maps 1 and 2.—*Polanisia trachysperma* T. & G., Fl. N.A. 1: 669. 1840. *Jacksonia trachysperma* (T. & G.) Greene, Pittonia 2: 174. 1891. *Cleome trachysperma* (T. & G.) Pax & K. Hoffm. in Engl. & Prantl. Nat. Pflanzenfam. (ed. 2) 17b: 215. 1936.

"Dry plains and hills, in the Lower and Upper Sonoran zones" (Wooton & Standley). In sandy river bottoms, washes, volcanic ash slopes, oak thickets, pinon-juniper stands, cultivated fields, and roadsides, at elevations of 4000–8100 feet. Flowering from end of June to end of September.

Rocky Mountains and Great Basin, south and east to central New Mexico, Texas, and Missouri.

1b. POLANISIA DODECANDRA ssp. UNIGLANDULOSA (Cav.) Iltis, Brittonia 10: 42. 1958. Maps 1 and 2.—*Cleome uniglandulosa* Cav., Ic. 4: 3, tab. 306. 1797. *Polanisia uniglandulosa* (Cav.) DC., Prodr. 1: 242. 1824.

"Dry plains and hillsides in the Lower and Upper Sonoran zones" (Wooton & Standley). In sandy washes and river sides, arroyos, and rocky hillsides, at elevations of 4000–6000 ft. or more. Flowering from mid May to early October.

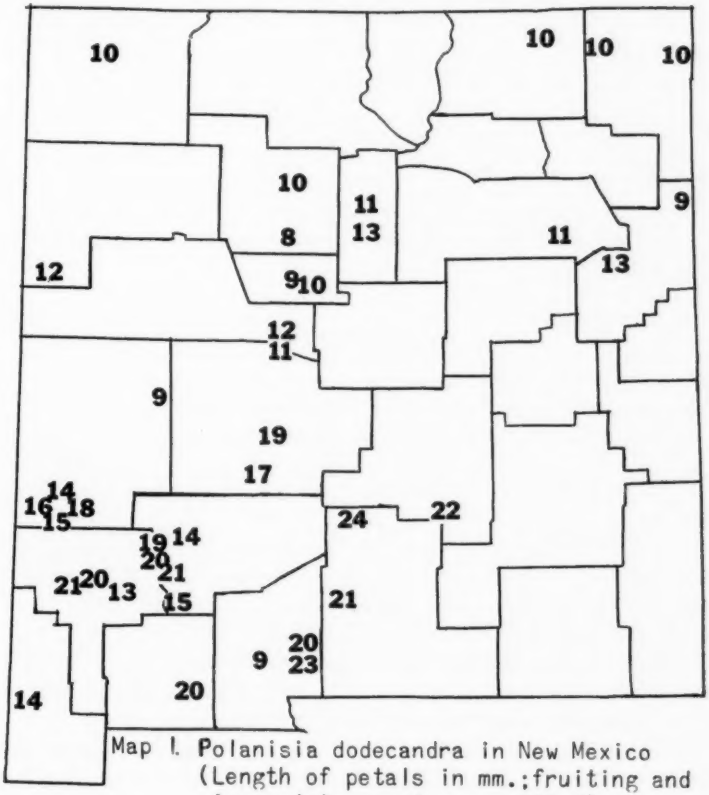
Southern Texas and New Mexico to Chiapas. In New Mexico in the southwestern quarter, especially in the Mogollon and Organ Mountains and the Black Range.

Judging from herbarium material, the two subspecies are distinguished from each other, in addition to the seed coat texture differences, by flower size correlated with geography. That is, petals, stamen, and style lengths are greater in ssp. *uniglandulosa* than in ssp. *dodecandra* var. *trachysperma*, as is stamen number. Petal color may be an additional correlated character, that of ssp. *uniglandulosa* being reported as sulfur yellow by Wooton and Standley. Whether this is a good field character, or was determined from herbarium material—the petals of this subspecies do often dry yellow—must be clarified by field work. All other Polanisias have white, cream-colored or pinkish petals. Map 1 shows distribution of petal length in New Mexico. It may be seen that a rather abrupt decrease in size occurs north of the upper San Francisco Valley and the Plains of St. Augustine, where, for taxonomic purposes, the geographic boundary between the two entities is taken to be, although their geographic limits may yet be shown to be clinal in nature.

2. POLANISIA JAMESII (T. & G.) Iltis, Brittonia 10: 54. 1958. Map 3.—*Cristatella jamesii* T. & G., Fl. N.A. 1: 124. 1838.

Branched, viscid-pubescent, annual herbs 15–30 cm. tall. Petioles 2–12 mm. long. Leaflets linear, 1–4 cm. long, 1–4 mm. wide. Bracts present (small foliage leaves), the upper reduced and 1-foliolate. Sepals 1.5–2.0 mm. long, lanceolate, deciduous. Petals spatulate, abruptly contracted to a slender claw, deeply laciniate, with 3–6 lobes 3–4 mm. long, whitish-cream. Gland a hollow tube 2–4 mm. long, less than 1 mm. thick, yellow (or orange?). Stamens 6–10, 3–5 mm. long. Style 1 mm. long, stiff, persistent in fruit. Siliques oblong-fusiform to linear, 2–3 cm. long, 3–4 mm. thick; pedicel 5–18 mm. long. Seeds several to many, rusty brown.

No New Mexican collections are known. To be expected in the state in both the northeastern and southeastern corners, having been collected in adjoining states within a few miles of the border, in sandy



Map 1. Polanisia dodecandra in New Mexico (Length of petals in mm.; fruiting and incomplete specimens omitted)

areas, wind-blows, dunes, and river sides. Flowering from end of May to end of October.

Great Plains from W. Texas to E. Colorado, N.W. Wisconsin, W. Illinois, and S.-Cent. Oklahoma.

2. CLEOME L., Sp. Pl. (ed. 1) 2: 671. 1753.

The genus is of world-wide distribution; all the New Mexico species belong to Sect. *Peritoma*, to which the following synonymy and description apply. Its 6 known species are restricted to W. North America.

Peritoma DC., Prodr. 1: 237. 1824.

Cleome sect. *Peritoma* (DC.) Baillon, Hist. Pl. 3: 149. 1872.

Erect, unarmed, slender to robust annuals, ours glabrous, glaucous. Leaves 3- to 5-foliolate; leaflets entire, mucronate, less than 6 cm. long; stipules minute, filiform. Racemes terminal, greatly elongating in fruit, bracteate. Corolla closed in bud. Sepals (in our species) basally fused; petals sessile or subsessile, (4–)6–12(–17) mm. long. Disk cylindric below, expanded above, produced adaxially into a gibbous or flattened appendage. Stamens 6, the anthers tightly coiled when dry. Fruits elongate siliques borne on distinct gynophores, the valves freely deciduous at maturity; styles persistent, indurate and setaceous in fruit; seeds many, free-falling, the two claws fused nearly their whole length by a hard membrane (of the testa?), with a minute or usually no internal sinus between them, the testa smooth or colliculate, frequently with small, soft blisters, often mottled.

KEY TO SPECIES

1a. Petals yellow; leaflets mostly 5. .....1. *C. lutea*

1b. Petals purple to pink or occasionally white; leaflets 3

2a. Leaflets narrowly elliptic, 5 mm. or more wide; bracts of inflorescence 1-foliolate; plants usually robust. ..2. *C. serrulata*

2b. Leaflets linear, 2 mm. or less wide; bracts similar to foliage leaves, all 3-foliolate; plants slender. .....3. *C. multicaulis*

1. CLEOME LUTEA Hook., Fl. Bor.-Am. 1: 70, t. 25. 1830. Map 3.—*Peritoma aurea* Nutt., Journ. Acad. Phila. 7: 15. 1834. *Peritoma luteum* (Hook.) Raf., Sylva Tellur. 112. 1838. *Peritoma breviflorum* Woot. & Standl., Contrib. U.S. Nat. Herb. 16: 128. 1913. (Type: *P. C. Standley 7282*, (US!) dry hills, vicinity of Shiprock, San Juan Co.) *Cleome breviflora* (Woot. & Standl.) Pax & K. Hoffm. in Engl. & Prantl, Nat. Pflanzenfam. (ed. 2) 17b: 215. 1936.

Erect annual herbs 8–75 cm. tall, simple or branched above, glabrous. Leaflets 5, or in upper leaves 3, narrowly lanceolate- to

oblanceolate-elliptic, 1.5–3.5 cm. long, up to 1 cm. wide. Flowers in dense short racemes. Petals yellow. Disk with flat, adaxial appendage. Siliques fusiform to linear-cylindric; pointed at both ends, 10–30 mm. long, 2–5 mm. wide; gynophore 4–5 mm. long; pedicel 7–14 mm. long. Seeds ovoid, 3.0–3.5 mm. long, brownish black or mottled light gray, blistered.

In dry sandy plains, hills, mesas, and draws, at 4500–6500 feet elevation. Flowering from beginning of April through June.

Widespread in the western United States; in New Mexico only in the northwestern corner (San Juan Co.).

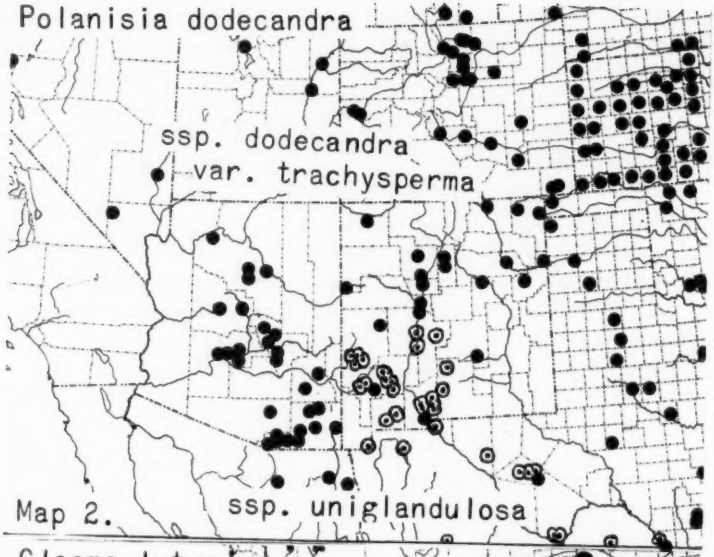
Most plants seen from New Mexico belong to a depauperate, small-fruited form (*C. breviflora*). *Cleome lutea* var. *jonesii* Macbr., Contrib. Gray Herb. 65: 39, 1922, with longer siliques, inflorescenes, and flowers, occurs from southeastern Arizona to Baja California, and should be looked for in southwestern New Mexico.

2. CLEOME SERRULATA Pursh, Fl. Am. Sept. 2: 441. 1814. Map 4.—*Peritoma serrulatum* (Pursh) DC., Prodr. 1: 237. 1824. *P. integrifolia* Nutt., Journ. Acad. Phila. 7: 14. 1834. *Cleome integrifolia* (Nutt.) T. & G., Fl. N.A. 1: 122. 1838. *C. albiflora* Cockerell, Proc. Acad. Phila. 48: 34. 1896. *C. serrulata* f. *albiflora* (Cockerell) Cockerell, Torreya 2: 42. 1902.

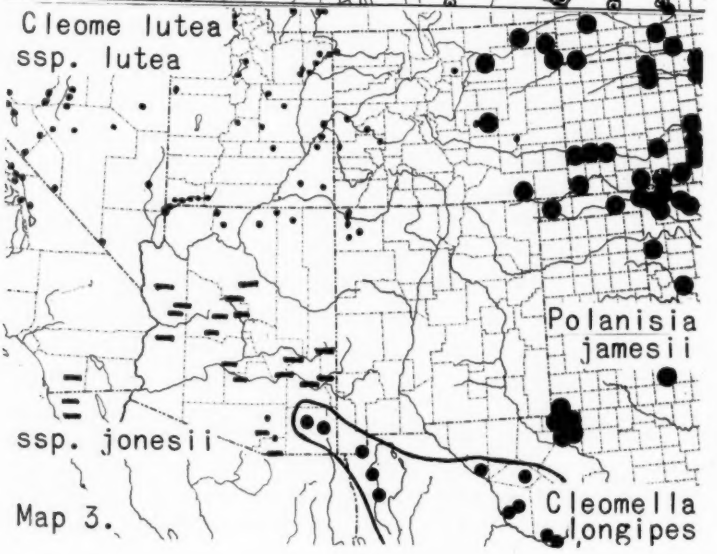
Erect annual herb 2–15 dm. tall, simple or branched, glabrous or subglabrous, glaucous. Leaflets 3, narrowly elliptic, 2–6 cm. long, 0.5–1.5 cm. wide. Flowers in dense racemes. Sepals united at base for ½–⅔ their length, persistent in fruit. Petals bright pink to purplish, rarely white (f. *albiflora*). Disk with adaxial apendage up to 4 mm. long; Siliques variable, linear-cylindric to fusiform, attenuate at both ends, 2–8 cm. long, 3–9 mm. wide; gynophore 11–23 mm. long; pedicel 14–20 mm. long. Seeds as in *C. lutea*, slightly larger.

In a variety of open habitats, moist or dry, gravelly, sandy or clayey river bottoms and banks, arroyos, dry meadows, and pinon-juniper woods in foothills, especially common along roadsides and waste places, at elevations of 4000–8500 feet. Flowering from June to October.

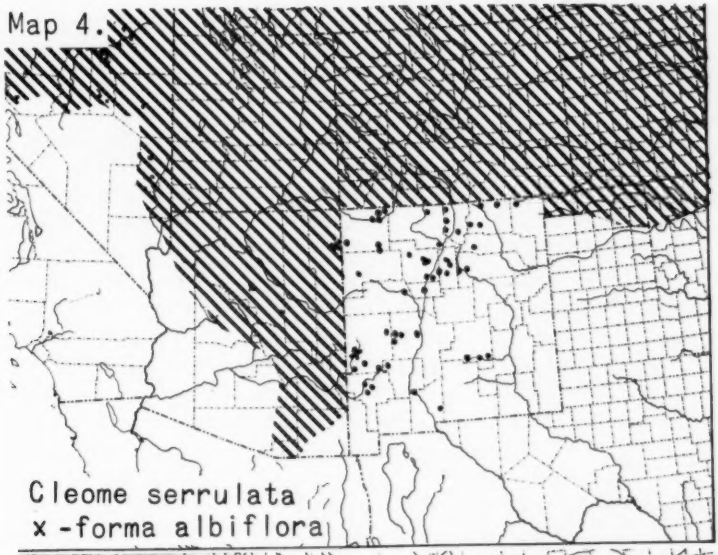
Widespread in western North America. Common in New Mexico, especially in the mountains, absent from near the southern and eastern borders of the state. Very similar in habit to *C. lutea*. It has been used for greens by the Navajos (E. Palmer), and reputedly has saved tribes from starvation. *Cleome serrulata* has been cultivated for nearly half a century as a honey plant, hence the common name,

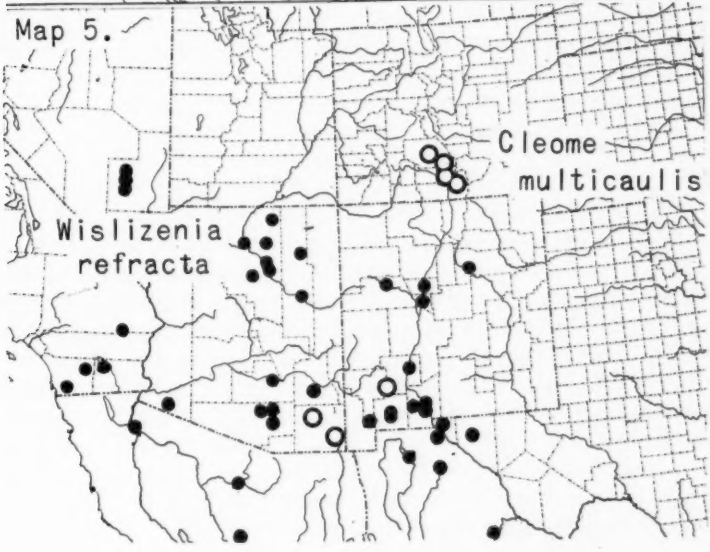

Polanisia dodecandra
ssp. dodecandra
var. trachysperma
ssp. uniglandulosa

Map 2.


Cleome lutea
ssp. lutea
Polanisia
jamesii
ssp. jonesii
Cleomella
longipes

Map 3.


Map 4.
Cleome serrulata
x -forma albiflora


Map 5.
Cleome
multicaulis
Wislizenia
refracta

"Rocky Mountain Bee Plant." It is reported as of poor palatability for livestock.

3. CLEOME MULTICAULIS Sessé & Mociño ex DC., Prodr. 1: 240. 1824. Map. 5.—*Cleome sonorae* A. Gray, Pl. Wright. 2: 16. 1853. *Peritoma sonorae* (A. Gray) Rybd., Bull. Torr. Bot. Club 33: 142. 1906.

Slender, erect, unbranched or sparingly branched, glabrous annual 20–75 cm. tall. Leaflets 3, linear and strongly folded, 6–35 mm. long, 1–3 mm. wide. Flowers subtended by 3-foliolate foliage leaves, in open elongate racemes. Petal pinkish purple. Disk bulbous. Siliques obovoid to linear, 9–18 mm. long, 2–4 mm. thick; gynophore 3–10 mm. long; pedicel 15–22 mm. long. Seeds subglobose, light brown, 1.8–2.5 mm. long, smooth.

Alkaline sinks, old saline lake beds, etc., in *Larrea* belt, at elevations of ca. 3000 ft. Flowering from June through August.

South central Colorado (San Luis Valley); southwestern New Mexico and adjacent Arizona to central Mexico. Two collections are said to have come from New Mexico. Both were collected on the Mexican Boundary Survey of 1851, with Pary, Bigelow, Wright, and Schott listed as collectors: "Near the Mibres, N. Mex., *Bigelow*" (evidently the Mimbres Mts., Grant Co.) (NY, US); "Valley of the Rio Grande below Donana" (US). Whether the second collection actually came from the stated locality is doubtful, for it has not been found since in that well-collected area, and Standley states (Contrib. U.S. Nat. Herb. 13: 146, 1910) that few of the specimens so labelled actually came from there.

3. CLEOMELLA DC., Prodr. 1: 237. 1824.

Cleome sect. *Cleomella* (DC.) Baillon, Hist. Pl. 3: 149. 1872.

Erect, slender to robust annuals. Leaves 3-foliolate; leaflets entire, mucronate, less than 4 cm. long; stipules minute, filiform. Racemes terminal, bracteate. Sepals minute, barely fused at base. Corolla yellow, closed in bud; petals subsessile. Disk small. Stamens 6, equal; anthers tightly coiled when dry. Fruit an obdeltoid or rhomboidal silicle, wider than long, compressed contrary to the placenta; valves conical, deciduous; gynophore elongate; style persistent, indurate. Seeds 6–20, as in *Cleome* sect. *Peritoma*, but smaller.

Endemic to W. United States and Mexico, with 10 species. Very closely related to *Cleome* sect. *Peritoma*, from which it differs primarily in characters of the fruit.

1. CLEOMELLA LONGIPES Torr. ex Hook., Jour. Bot. & Kew Misc. 2: 255. 1850. Map 3.

Glabrous, erect, branched annuals 3–8 dm. tall. Leaflets 3, oblanceolate to oblong-oblanceolate, 15–30 mm. long, 4–10 mm. wide. Racemes well defined, dense, greatly elongating in fruit, to 30 cm. long, bracteate or the upper portions ebracteate. Petals yellow, 6–9 mm. long. Mature silicles obdeltoid or rhomboidal, 4–8 mm. long, 6–10 mm. wide; style 1–2 mm. long; gynophore 6–17 mm. long; pedicel 5–15 mm. long. Seeds 6–16 in each silicle, obovoid, 1.9–2.4 mm. long, when mature dark brown.

In saline, alkaline soils or sands of semideserts, etc., at elevations of about 5000 ft. Flowers from May to September.

Southeastern Arizona to W. Texas and central Mexico. In New Mexico known only at Dog Springs, Dog Mts., in extreme southern Hidalgo Co.: *Mearns 2379* (US), *Hershey s.n.* (Herb. N.M. State College).

4. WISLIZENIA Engelm. in Wislizenus, Mem. Tour. N. Mexico 99. 1848.

Robust, erect, glabrous annual, sparsely to densely branched. Leaves 3-foliolate or the upper 1-foliolate; leaflets less than 4 cm. long, entire, mucronulate. Stipules minute tufts of filiform hairs. Racemes terminal, ebracteate or rarely the very lowest flowers bracteate, dense, not markedly elongating in fruit. Sepals minute, tardily deciduous. Corolla closed in bud; petals yellow, subsessile. Disk small. Stamens 6, the anthers tightly coiled when dry. Fruit a schizocarp with 2 divaricate or deflexed, obovoid to obconical nutlets, each containing 1 (rarely 2) seeds which are permanetly enclosed by the capsule valves; placenta a ring 1 mm. or less in diameter; style, gynophore, and pedicel slender. Seeds obovoid, pointed, with fused claws.

A monotypic genus, the one species highly polymorphic.

1. WISLIZENIA REFRACTA Engelm. in Wislizenus, l.c. Map 5.

Annual 4–7 dm. tall. Petioles 5–35 mm. long. Leaflets oblanceolate, elliptic to oblong-ovate, 5–35 mm. long, 3–11 mm. wide, the apex rounded, the base attenuate into slender petiolules up to 4 mm. long. Racemes 0.5–3.0(–8.0) cm. long, very dense, at the tip of each branch. Petals 2–4 mm. long. Stamens 6–7 mm. long. Pistil long-exserted. Style 4–6 mm. long in fruit, very slender; gynophore 3–7 mm. long, strongly refracted against a pedicel 4–10 mm. long. Nutlets obovoid, 1.5–2.5 mm. long, smooth to veined, minutely to markedly tuberculate at distal end, 1–2-seeded; seed smooth, yellow.

"Lower Sonoran Zone" (Wooton & Stanley). In alkaline, sandy or loamy soils of semideserts, on edges of playas, grasslands (*Hilaria* association), river-sides, and common on roadsides, at elevations of 3850–5200 feet. Flowering from mid July through September.

Western-most Texas and northern Mexico to Nevada and Baja California; in New Mexico in the southwestern ⅔, there rather common. Type locality in the Rio Grande Valley near El Paso, Texas.

REFERENCES

ILTIS, HUGH H. 1954. Studies in the Capparidaceae. I. *Polanisia dodecandra* (L.) DC., the correct name for *Polanisia graveolens* Rafinesque. Rhodora 56: 65–70.

————. 1955. Caparidaceae of Nevada, in W. A. Archer, Contrib. Fl. Nevada No. 35. 24 pp.

————. 1956. Studies in the Capparidaceae—II. The Mexican species of *Cleomella*. Madroñn 13: 77–89.

————. 1957. Studies in the Capparidaceae. III. Evolution and phylogeny of the western North American Cleomoideae. Ann. Mo. Bot. Gard. 44: 77–119.

————. 1958. Studies in the Capparidaceae—IV. *Polanisia*. Brittonia 10: 33–58.

PAYSON, E. B. 1922. A synoptical revision of the genus *Cleomella*. Univ. Wyo. Publ. Sci. 1: 29–46.

WOOTEN, E. O., and PAUL C. STANLEY. 1915. Flora of New Mexico. Contrib. U.S. Nat. Herb. 19. Capparidaceae, pp. 289–291.

THE SOUTHWESTERN NATURALIST 3: 145–153 1958 (PRINTED 1959)

A MONOGRAPH OF THE GENUS *ROSA* IN NORTH AMERICA. II. *R. FOLIOLOSA*[1]

WALTER H. LEWIS

Blandy Experimental Farm, University of Virginia, and Stephen F. Austin State College, Nacogdoches, Texas

ABSTRACT. The study of *Rosa foliolosa* Nutt. is discussed under the disciplines of gross- and micro-morphology, phytogeography, cytology, and taxonomy.

Rosa foliolosa Nutt. is a remarkably distinct species within the section *Cinnamomeae* and the subgenus *Eurosa* (Lewis 1957). First published by Torrey and Gray (1840) from a manuscript by Nuttall, the species is described with:

> "branches slender, glabrous, armed with very weak scattered deciduous bristly prickles, and sometimes with persistent short and nearly straight stipular prickles; leaflets 7–11, linear-oblong, glabrous, shining above, sharply serrate, crowded, the lower pair close to the narrow glandular-ciliate stipules; the petiole midrib often setose and pubescent; flowers mostly solitary and almost sessile; calyx glandular-hispid; the segments reflexed, often with lateral appendages; fruit subglobose, somewhat hispid."

To Nuttall's description, Torrey and Gray added several phrases of questionable validity. One especially have created a minor intraspecific problem, i.e., their "flowers small, apparently rose-color." The rose coloured petals have been considered typical of *R. foliolosa* and this quite naturally has led to the naming of the white petalled individuals as var. *alba* Bridwell and as f. *alba* (Bridwell) Rehder. From the holotype collected on the 'Arkansana plains' and now housed in the Gray Herbarium, it is impossible to determine if rose or white petals were a part of the Nuttall collection. It is of interest, however, that white petalled individuals occur (as observed in Texas by Dr. L. H. Shinners and myself) more frequently than do the pink, although extremely light pink to rose colours may be discerned (especially in Oklahoma). Certainly the occurrence of white is not as a result of an

[1] All techniques and methods used in this study are similar to those described for the monographic treatment of *Rosa acicularis* Lindl (Lewis 1959).

uncommon gene(s) expression as a forma should be. To actually determine in the field whether a plant has light pink or more-white-than-pink etc. coloured petals is indeed a difficult task, and it would, I fear, lead to quite diverse conclusions depending upon individual judgment. With an herbarium specimen lacking a collector's notation or poorly dried (and what if a collection was made after flowering?) it would be even more difficult to determine a specimen's petal colour. When consistency and accurracy are obviously going to be wanting in these intraspecific determinations, how can any taxon be used to identify the character of petal colour in *R. foliolosa?*

To specimens recorded from the Arkansas prairies and from Texas, Torrey and Gray (1840) extend with reservation the range of *R. foliolosa* to East-Florida. No specimens are cited, but surely the authors were recording the small leaflet form of *R. palustris* Marsh. (= *R. floridana* Rydb.), frequently collected in Florida and which, on herbarium sheets ,superficially resembles this species.

Rosa ignota Shinners is described (1958) as having small, few (1–5) leaflets with the uppermost coarsely serrated. Mention is made of an apparent gall formation (and, after examining the holotype, I concur) at the base of the floral branch described, suggesting that the results of gall formation were expressed by this morphology. A second galled specimen has been examined from the Tracy Herbarium, A & M College of Texas (Bell's Ranch, Ellis County, Texas, *R. Mauldin 1378*), and although the marked morphology of *R. ignota* is not evident, this specimen does have smaller and fewer leaflets than occur in individuals determined as *R. foliolosa.* Both specimens do, however, have the distinct characters of lanceolate, glossy leaflets, short pedicels, and glandular pedicels and hypanthia typical only of *R. foliolosa.*

GROSS MORPHOLOGY

Fifty specimens, chosen at random from the collections of several herbaria, served to characterize the species gross morphology for twenty-six different characters. The data from these are summarized in Table 1.

Several characters are especially useful in differentiating this species from all others. The small width of the leaflets ($\bar{x}$ = 5.6 mm.) is characteristic of *R. foliolosa* and although the length of the leaflet is not distinctive in itself, the ratio of width to length is different from other species. The leaflet length is between three and four times as long as the width giving a typically lanceolate leaflet. The pedicels are only $\bar{x}$=5.4 (s=± 2.8) mm. long, by far the shortest pedicels of any

TABLE 1

Gross Morphological Data for *R. foliolosa*

50 individuals sampled	Measurements in mm. Statistics		
Character	Mean	s	sx
Leaflet width	5.6	1.2	0.17
Leaflet length	20.0	3.9	0.56
Leaflet width / Leaflet length	0.28	0.04	0.01
Serrations per half leaflet	14	3	0.41
Auricle length	2.7	0.5	0.08
Sepal width	2.6	0.4	0.08
Sepal length	16.2	3.5	0.50
Pedicel length	5.4	2.8	0.40
Flowers per inflorescence	1.5	0.8	0.12

Character	Percent		
	Absent	Present	
Armature of floral stems	14	86	
	Thorns (infrastipular)		
Kind of floral stem armature	100		
	Single	Single & Double	Double
Kind of leaflet serration	98	2	0
	Fine	Dentate	Acute
Shape of leaflet serrations	6	92	2
	Absent	Few	Numerous
Leaflet serration glands	28	72	0
Leaflet glands below	100	0	0
Leaflet pubescence above	100	0	0
Leaflet pubescence below	96	4	0
Stipule glands	22	78	0
Petiole bristles	0	52	48
Petiole glands	0	2	98
Petiole pubescence	72	28	0
Sepal glands	0	0	100
Sepal pubescence	50	50	0
Sepal bristles	100	0	0
Pedicel glands	6	22	72
Pedicel pubescence	98	2	0
Hypanthium glands	2	8	90

rose in the section *Cinnamomeae*. The stems are usually armed (86%) and when armature is present, the fine thorns or prickles have been found only in an infrastipular position either in pairs or singly. Leaflet margins are almost consistently serrulate and single, and all specimens examined lacked glands on the lower epidermis of the

leaflets, excluding the mid-vein, and were without pubescence on the upper epidermis.

MICROMORPHOLOGY

Pollen Grains. From seven individuals of *R. foliolosa*, a total of 245 pollen grains were measured along one germinal furrow giving a mean diameter of 27.8 u (Table 2). The mean pollen range of from 26.5 to 29.5 u illustrates the consistency in size of these cells even when the samples were selected over an area of hundreds of square miles.

The percentage of abortive pollen is low (7–26%) in six individuals and only in one, a specimen from Tarrant County, Texas, is it considerably higher (40%). No reason for this more extensive abortive condition is apparent.

Guard Cells. The lengths of guard cells from two individuals were measured. These measurements, $\bar{x} = 23.7$ u and $\bar{x} = 21.6$ u (Table 2) correspond in size with those for other diploid species in the section *Cinnamomeae* (e.g., *R. blanda* Ait., $\bar{x} = 21.5$ u; *R. Woodsii* Lindl., $\bar{x} = 23.5$ u; *R. nitida* Wendl., $\bar{x} = 24.0$ u).

TABLE 2

Micromorphological Data for *R. foliolosa*

Locality	Pollen Grains Diameter in micra				Abortive
	No.	Mean	s	$s\bar{x}$	Per cent
Oklahoma: Comanche Co.[1]	35	26.5	1.4	0.24	11
Oklahoma: Creek Co.	35	27.6	1.3	0.22	8
Oklahoma: Murray Co.	35	28.8	1.2	0.20	14
Oklahoma: Muskogee Co.	35	27.7	1.4	0.24	21
Texas: Dallas Co.	35	27.8	1.3	0.22	26
Texas: Denton Co.[2]	35	29.5	1.5	0.25	7
Texas: Tarrant Co.	35	26.5	1.3	0.22	40
	245	27.8	1.7	0.11	
	Guard cells (from living plants)				
Arkansas: Polk Co.[2]	25	23.7	2.1	0.42	
(from USDA collection)[2]	25	21.6	2.7	0.54	

[1] For complete citations, see Selected Specimens Examined.
[2] Specimens examined for chromosome numbers (all $2n = 14$).

PHYTOGEOGRAPHY

Rosa foliolosa is native to Oklahoma, western Arkansas, and central and north-eastern Texas (Figure 1). This distribution is one of the most limited of any species in the section *Cinnamomeae*. Populations might be expected to occur in the extreme southwestern counties of Missouri and in southern Kansas, although during a collecting trip in this area I failed to find *R. foliolosa*. A possible extension of the known

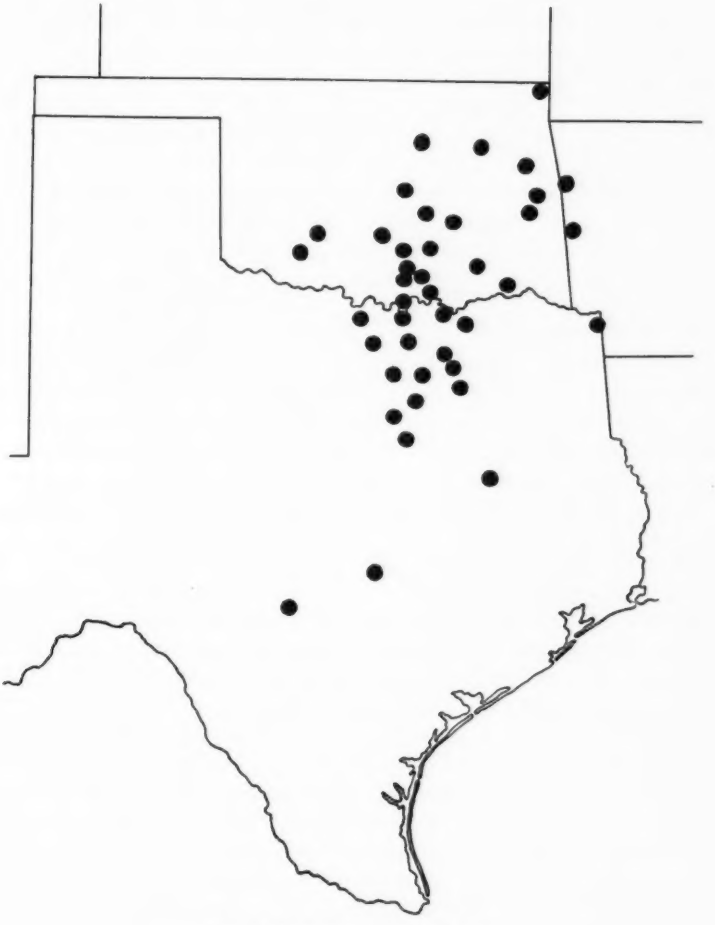


Fig. 1. Distribution of *Rosa foliolosa*.

range would seem likely in south-central Texas toward the Mexican border where as yet collections of *Rosa* are rare.

Selected Specimens Examined (only one collection from each county is listed and each is recorded on Figure 1).

ARKANSAS. Polk Co.: Rich Mountain, *E. W. Erlanson 9529*, *Lewis 2564* (as var. *alba*) (MICH); Sebastian Co.: Fort Smith, *J. M. Bigelow*, 1853–54 (US).

OKLAHOMA. Atoka Co.: 2 mi. n.e. Atako, *G. T. Robbins 2568* (as *R. humilis* (OKL); Caddo Co.: between Ft. Cobb & Ft. Arbuckle, *E. Palmer 70* (US); Carter Co.: 12 mi. n. Ardmore, *F. Rinehart 196* (as *R. humilis*) (OKL); Choctaw Co.: 3 mi. n.e. Norman, *B. Neill 55* (as *R. setigera*) (OKL); Comanche Co.: Wichita Natl. Forest, *D. Demaree 12998A* (OKL); Creek Co.: 3 mi. w. Sapulpa, *U. T. W. 2060* (as *R. carolina* var. *glandulosa*) (OKL); Garvin Co.: Arbuckle Mts., near Turner Falls St. Pk., *E. J. Palmer 42016* (H); Haskell Co.: 10 mi. s. Keota, *W. W. Barkley* (as *R. virginiana*) (OKL); Hughes Co.: Wetumka, *E. W. Erlanson 9525* (MICH); Johnston Co.: Mannsville, *F. Griffith 3484½* (as *R. foliosa*) (H); Latimer Co.: n. Red Oak, *O. M. Clark 2842* (as *R. humilis*) (OKL); Love Co.: Marietta, *E. J. Palmer 10404* (H); McClain Co.: 3 mi. e. Washington, *M. Hopkins 1179* (H, OKL); Marshall Co.: 5 mi. w. Kingston, *A. Wilson*, 12 July 1950 (as *R. Woodsii*) (SMU); Murray Co.: 6 mi. n. Sulfur, *M. Hopkins 5886* (OKL); Muskogee Co.: *R. Bebb 4280* (OKL); Oklahoma Co.: 1 mi. s. Harrah, *U. T. Waterfall 2868* (H); Ottawa Co.: Miami, *G. W. Stevens 2159* (H), *2322* and *2519* (OKL, US); Payne Co.: Stillwater, *F. A. Waugh 125* (US); Pontotoc Co.: E. C. College campus, *D. McCoy 705* (SMU); Pottawatomie Co.: 3 mi. w. Earlsboro, *M. Hopkins & D. Demaree 25* (OKL).

TEXAS. Bowie Co.: near Texarkana, *A. A. & E. G. Heller 4184* (as *R. humilis*) (US); Collin Co.: near Plano, *C. L. & A. A. Lundell 9299* (H, MICH, SMU); Cooke Co.: Red River, n. Gainesville, *R. McVaugh 6933* (MICH, SMU); Dallas Co.: vicinity Dallas, *M. R. Stephenson*, 17 May 1939 (US); Denton Co.: 4 mi. e. Denton, *W. H. & M. E. Lewis* 3542 (ASTC, SMU); Ellis Co.: ⅔ mi. s. w. Midlothian, *V. L. Cory 57951* (SMU); Fannin Co.: 9 mi. e. Bonham, *R. McVaugh 7136* (SMU); Freestone Co.: near Oakwood, *E. J. Palmer 13396* (H, US); Grayson Co.: 2 mi. n. Denison, *R. McVaugh 7124* (MICH, SMU); Hill Co.: near Hillsboro, *S. E. Wolff 3306* (US); Johnson Co.: Cleburne State Park, s. w. Cleburne, *N. Stillwell*, 21 June 1946 (as *R. ignota*, holotype) (SMU); Kaufman Co.: 2 mi. e. Terrell, *L. H. Shinners 10091* (SMU); Kerr Co.: 7.5 mi. n. e. Kerrville, *R. McVaugh 7067* (MICH, SMU); Montague Co.: *E. W. Erlanson 9526* (MICH);

Rockwall Co.: *H. Ness*, 5 Oct. 1923 (as *R. humuilis*) (TAES); Tarrant Co.: *A. Ruth 297* (MICH, PENN, US); Travis Co.: Austin, *F. Rugel*, purchased 1881 (PENN); Wise Co.: 5.7 mi. n. Rhome, *E. Whitehouse 10681* (SMU).

CYTOLOGY

The chromosome number of 2n = 14 was established for *R. foliolosa* by Hurst (1928); later to be verified by Erlanson (1929, 1934) in PMC studies (n = 7). In the latter works, meiosis was found to be regular.

In PMC from a plant collected in Polk County, Arkansas, three meiotic plates at metaphase I had six normal bivalents while the seventh bivalent in each case was well advanced into anaphase I. The

Figure 2–3. Chromosomes of *R. foliolosa* (drawn with a camera lucida for a total magnification of x4200). 2. *Lewis 2564*, PMC metaphase I with 6 II and 2 I (precocious separation). 3. *Lewis 2564*, leaflet metaphase with 2n=14.

metaphase II plates were all regular with seven chromosomes each. The condition at metaphase I was thus assumed to be a precocious separation of one bivalent without any effect upon the chromosome number of the gametes (Figure 2).

Although the mitotic leaf chromosomes from only one plant were studied in detail, several plates from this specimen showed the following karyotype (Figure 3):

1 pair long median chromosomes (aa)
1 pair long subterminal chromosomes (cc)
2 pairs medium median chromosomes (dd, dd)
1 pair medium submedian chromosomes (ee)
1 pair medium subterminal chromosomes (ff)
1 pair short median chromosomes (gg).

This morphology is similar to that for one form of *R. Woodsii* Lindl. except that—as observed here—one pair of long chromosomes has a median centromere in *R. foliolosa* and the corresponding pair in *R. Woodsii* has a submedian centromere. The chromosome morphology of *R. foliolosa* is also similar to a second diploid species, *R. palustris* Marsh. The latter has a long submedian pair (bb) and two pairs of medium subterminal chromosomes (ee, ee), while *R. foliolosa* has a long median pair (aa) and only one pair of medium subterminal chromosomes (ee).

A summary of the chromosome work completed for this species is found in Table 3.

TABLE 3

Chromosome Numbers Reported for *R. foliolosa*

Locality[1]	n	2n	Author
"Texas, Oklahoma, Arkansas"	..	14	Hurst (1928)
Oklahoma: Hughes Co.	7	....	Erlanson (1929)
Texas: Montague Co.	7	....	Erlanson (1929)
"United States"	7	14	Erlanson (1934)
Arkansas: Polk Co.	7	14	*Lewis 2564*
Texas: Denton Co.	..	14	*Lewis 3542*
"USDA collection"	..	14	*Lewis 2515*

[1] Except for those with quotation marks, data are given for each collection under Selected Specimens Examined.

TAXONOMY

ROSA FOLIOLOSA Nuttall *ex* Torrey and Gray, Flora North America 1: 460 (1840).

R. foliolosa Nutt. var. *alba* Bridwell, Am. Fl. 22: 8 (1926).

R. foliolosa Nutt. f. *alba* (Bridwell) Rehder, Bibl. Cult. Trees & Shrubs 305 (1949).

R. ignota Shinners, Spring Fl. Dallas-Fort Worth Area Texas 409 (1958).

Holotype. Arkansana plains, *Nuttall* (H).

Description (summary of 50 specimens studied in detail).

Stems low, 2–6 dm. tall, armed with infrastipular fine thorns (86%) or without armature (14%) on the floral branches; leaves 5–11 foliolate, usually 9; leaflets lanceolate, shining above, $\bar{x}=5.6$ ($s=1.2$) mm. wide, $\bar{x}=20.0$ ($s=3.9$) mm. long, the ratio of leaflet width to length $\bar{x}=0.28$ ($\bar{x}=0.04$), glabrous above, glabrous (96%) or slightly pubescent (4%) below, eglandular below, leaflet magin serrulate, $\bar{x}=14$ (s

=3) serrations per half leaflet, serrations single (98%) or rarely somewhat biserrate (2%), eglandular (28%) or slightly gland-tipped (78%); petioles with few (52%) or many (48%) bristles, glandular, glabrous (72%) or somewhat pubescent (28%), these characters often extending from the petiole to the leaflet mid-vein below ;stipules adnate, eglandular (22%) or slightly glandular (78%) on the margin and outer surface, one auricle $\bar{x}=2.7$ (s=0.5) mm. wide; inflorescence 1–5 flowered, generally with one flower, $\bar{x}=1.5$ (s=0.8); pedicels $\bar{x}=5.4$ (s=2.8) mm. in length, glabrous (98%) or rarely somewhat pubescent (2%), eglandular (6%), slightly glandular (22%), or with numerous glands (72%); sepals $\bar{x}=2.6$ (s=0.4) mm. wide at the base, $\bar{x}=16.2$ (s=3.5) mm. long, glabrous (50%) or with slight pubescence (50%), glandular, without bristles on the outside, tomentose within; petals white, pink, or with intermediate shades; hypanthium subglobose, glabrous, eglandular (2%), somewhat glandular (8%), or glandular (90%); pollen grains $\bar{x}=27.8$ (s=1.7) u in diameter; guard cells $\bar{x}=22.7$ (s=2.4) u in length; chromosome number 2n=14.

From the data presented in Table 1 and the descriptive summary of the characters of *R. foliolosa*, it is apparent (for this sample studied) that the individuals exhibit an extensive degree of homomorphism. There is no doubt, however, that intraspecific variation does exist. Petal colour from white to pink, peculiar modifications from galls, as well as others mentioned in the species description, are known examples. Regardless, the populations of this taxon are more consistent for both morphological and cytological characters than are those of most rose species. Its limited range and its geographical isolation from diploid *Cinnamomeae* species (except a partial distribution overlap with *R. Woodsii* Lindl.) have undoubtedly contributed to this unique phenomenon in the North American *Rosa*.

LITERATURE CITED

ERLANSON, E. W. 1929. Cytological conditions and evidences for hybridity in North American wild roses. Bot. Gaz. 87: 443–506.

————. 1934. Experimental data for the revision of the North American wild roses. Bot. Gaz. 96: 197–259.

HURST, C. C. 1928. Differential polyploidy in the genus *Rosa* L. Zeitschr. Indukt. Abstam. Vererb. Supp. 2: 866–906.

LEWIS, W. H. 1957. An introduction to the genus *Rosa* with special reference to *R. acicularis*. Va. J. Sci. 8: 197–202.

————. 1959. A monograph of the genus *Rosa* in North America. I. *R. acicularis*. Brittonia 11: 1–24.

SHINNERS, L. H. 1958. Spring Flora of the Dallas-Fort Worth Area Texas. Dallas. 514 p.

TORREY, J. and A. GRAY. 1840. Flora of North America. Vol. I. New York. 711 p.

THE SOUTHWESTERN NATURALIST 3: 154–174 1958 (PRINTED 1959)

A MONOGRAPH OF THE GENUS *ROSA* IN NORTH AMERICA. III. *R. SETIGERA*[1]

WALTER H. LEWIS

The Blandy Experimental Farm, University of Virginia, and Stephen F. Austin State College, Nacogdoches, Texas

ABSTRACT. The study of *Rosa setigera* Michx. (a diploid species in the section *Synstylae*) is discussed under the disciplines of gross- and micro-morphology, phytogeography, ecology (transplant experiments), cytology, and taxonomy.

Walter (1788) added to his description of *R. carolina* L. 1762 (= *R. palustris* Marsh.): "*varietates, calycis laciniis brevibus integris; et longis laciniatis.*" This is a clear reference to *R. setigera* as named and described by Michaux (1803) from material collected in lower Carolina and Georgia. Several striking characters in his description include stems with paired prickles, glabrous leaves, each 3 to 5 foliolate, and leaflet veins, petioles and sepals, hispid. Michaux also cited a variety of *R. setigera* with taller stems and scattered prickles having leaflets pubescent near the veins below and sepals with fewer bristles. Persoon (1806) called this variation with "leaflets pubescent toward the veins" var. *elatior*. Aiton f. (1811) described *R. rubifolia* based upon a form with pubescent leaflets which had been introduced into the gardens of England. Lindley (1820) felt he could distinguish between *R. setigera* Michx. and *R. rubifolia* Ait. f. apart from the presence or absence of pubescence on the leaflets and established *R. rubifolia* var. *fenestralis* as a glabrous leafed form of *R. rubifolia*. This variety is synonymous with the typical *R. setigera*.

In 1820, Refinesque duplicated the work of Persoon (1806) and described *R. setigera* var. *pubescens*, a form with pubescent leaflet veins, but otherwise glabrous. He further described three species, *R. kentukensis*, *R. cursor*, and *R. trifoliata*, the former two descriptions approaching *R. rubifolia* while *R. trifoliata* is *R. setigera*.

The division of this complex at the specific level into individuals with leaflets glabrous below or with leaflet veins pubescent (*R. setigera*) and into individuals with leaflets puberulent, pubescent, or to-

[1] All techniques and methods used in this study are similar to those described for the monographic treatment of *Rosa acicularis Lindl.* (Lewis 1959b).

mentose below (*R. rubifolia*) was one approach followed in the last century and even until quite recent times (Rydberg 1918), especially by those who recognized no taxa below the rank of species. A more widely used treatment, however, is that proposed by Torrey and Gray (1840). They divided *R. setigera* into two varieties: (1) *glabra* with leaflets glabrous below, but including individuals with pubescent veins, and (2) *tomentosa* with leaflets entirely pubescent below. *Rosa rubifolia* was placed in synonymy under the latter variety.

Several minor forms have been described more recently. Palmer and Steyermark (1935) added two—*R. setigera* f. *inermis* (glabrous leaflets and unarmed stems) and *R. setigera* var. *tomentosa* T. & G. var. *serena* (tomentose leaflets and unarmed stems), the latter reduced to f. *serena* by Fernald (1948). A white petalled variant with somewhat smaller petals and pubescent leaflets is named *R. setigera* var. *tomentosa* f. *alba* Steyerm. (See Lewis 1959a).

GROSS MORPHOLOGY

From the states of Alabama, Arkansas, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Missouri, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Texas, Virginia, and West Virginia, a total of 100 specimens (chiefly collected at random by the author) were examined for twenty-six morphological characters. The data for these are summarized for each character in Table 1.

Using the data from this sample, *R. setigera* populations can readily be differentiated from all others in North America. Its leaves, usually three foliolate, have large leaflets ($\bar{x}$=27.2 mm. wide and 47.8 mm. long) of which almost all (97%) are entirely eglandular and with many, coarse serrations ($\bar{x}$=37 per half leaflet). The stems are long, often to 5 meters, and are usually armed with large-based, curved, scattered or infrastipular thorns. Glands are generally found on the stipules (99%), petioles (100%), sepals (100%), pedicels (100%), and hypanthia (100%). The sepals are wide at their bases ($\bar{x}$=2.7 mm.) and are early dehiscent from the pea-shaped hip. These characteristics serve to readily distinguish *R. setigera* from all other *Rosa* either in the section *Synstylae* (characterized by exserted styles united into a column) or in the more typically North American sections *Cinnamomeae* and *Minutifoliae*.

Because of the intraspecific importance given to the lower surface of the leaflets, two hundred additional specimens have been examined at random for the following leaflet expressions: glabrous, glabrous but with pubescent veins, puberulent, and pubescent. A fifth possible

TABLE 1

Gross Morphological Data for *Rosa setigera*

100 individuals sampled at random	Measurements in mm. Statistics		
Character	Mean	s	$s_{\bar{x}}$
Leaflet width	27.2	7.7	0.8
Leaflet length	47.8	12.0	1.2
Leaflet width / Leaflet length	0.57	0.07	0.007
Serrations per half leaflet	37	8.5	0.9
Sepal width	2.7	0.5	0.1
Sepal length	12.2	1.8	0.2
Auricle width	3.2	0.8	0.1
Pedicel length	14.2	4.5	0.5
Flowers per inflorescence	6	3	0.3

	Per cent		
	Absent	*Present*	
Armature of floral stems	7	93	
	Scattered & infra-stipular thorns		*Infrastip-ular thorns*
Kind of floral stem armature	90		10
	Single	*Single & double*	*Double*
Kind of leaflet serration	59	17	24
	Fine	*Dentate*	*Acute*
Shape of leaflet serrations	0	31	69
	Absent	*Few*	*Numerous*
Leaflet serration glands	18	69	13
Leaflet glands below	97	3	0
Leaflet pubescence above	98	2	0
Leaflet pubescence below	29*	30	41
Stipule glands	1	97	2
Petiole bristles	4	93	3
Petiole glands	0	36	64
Petiole pubescence	20	67	13
Sepal glands	0	3	97
Sepal pubescence	0	11	89
Sepal bristles	100	0	0
Pedicel glands	0	6†	94†
Pedicel pubescence	90	10	0
Hypanthium glands	0	18†	82†

* Leaflets completely glabrous below or with pubescent veins only.

† Often deciduous with age.

expression, *viz.* tomentose, separable from pubescence only with difficulty, is recorded with the latter (see details under Taxonomy below).

MICROMORPHOLOGY

Pollen Grains.—Of the fifteen individuals studied, only nine plants could be measured for pollen grain size (Table 2). These gave an average pollen diameter of 33.4 u (s=2.3 u) with a mean range of from 31.1 u to 36.0 u. This average is considerably larger than for five other diploid (2n=14) species ($\bar{x}$=27.9 u, s=2.3 u), including *R. foliolosa* Nutt., *R. nitida* Willd., *R. palustris* Marsh., *R. Woodsii* Lindl., and *R. blanda* Ait., studied for pollen size. Compared with three tetraploid species (*R. arkansana* Porter, *R. virginiana* Mill., *R. carolina* L.) having an average pollen diameter of 33.4 u (s=2.3 u), there is no difference in size—by random sampling, the average diameters and deviations for *R. setigera* and the tetraploid species pollen are exactly alike. It should be noted that all species here compared with *R. setigera* (section *Synstylae*) are in a distinct morphological group (section *Cinnamomeae*) as revised (Lewis 1957).

Completely abortive pollen was found in the remaining six individuals. A similar observation has been made by Erlanson (1934). Of these plants, two were examined at PMC meiosis (Fig. 1 at late diakinesis, *Lewis 2079*; Fig. 6 at diakinesis, *Lewis 2321*). From *Lewis 2079*, the following numbers of meiotically regular cells were recorded: 3 at diakinesis, 5 at metaphase I, 1 at anaphase I, and 1 at anaphase II. Six cells at metaphase I and 3 at metaphase II from *Lewis 2321* were all regular. No case of irregular meiosis was noted. The cytological evidence does not suggest a cause for the abortive pollen condition.

From one specimen, *Lewis 2079*, pollen was examined in each of two years (Table 2). In 1953, the pollen was removed from the plant in Alabama, and in 1955, the pollen was taken from the same plant after two years growth in Virginia. Examination in both years gave 100 per cent of abortive pollen. It seems doubtful, therefore, that sterility is due to environmental conditions. This view is strengthened when the specimen, *Lewis 2080* (collected from an almost identical habitat only 3 miles distant from *Lewis 2079*), was found to have only 8 per cent of abortive pollen.

Only pollen sterility has been mentioned thus far. Fruit development was also found to be quite irregular. Of fourteen plants examined in September, 1956 (arboretum plots, Blandy Experimental Farm, Boyce, Virginia), eight had mature hips containing seed while

TABLE 2

Pollen Grain and Guard Cell Measurements for *Rosa setigera*

Locality	Pollen Grains No.	*Diameter in micra* Mean	s	sx	Abortive Per cent
var. *setigera*					
Ala.: Marshall Co., 2 mi. n.	..	...	..	..	100(1953)
Guntersville, *Lewis 2079*[1]	..	...	..	..	100(1955)
Ga.: Cobb Co., 5 mi. w. Mariette, *Lewis 2078*	35	33.1	1.6	0.3	25
Ga.: Troup Co., Lagrange, *Tracy 9239*	35	32.6	1.7	0.3	4
Ohio: Medina Co., Medina, *Lewis 2307*[1]	35	31.1	1.5	0.3	40
Ohio: Tuscarawas Co., 4 mi. e. Newcomerstown, *Lewis 2321*[1]	..	...	..	..	100
var. *tomentosa*					
Ala.: Marshall Co., 5 mi. n. Guntersville, *Lewis 2080*	38	31.8	1.9	0.3	8
Ill.: Union Co., Cobden, *Boott* 19 June 1861	..	...	..	..	100
Kans.: Linn Co., Trading Post, *Lewis 2385*	..	...	..	..	100
Nebr.: Cass Co., Weeping Water, *Bates 5127*	35	33.1	1.9	0.3	16
Mo.: Pike Co., Eolia, *Davis* 24 June 1913	35	36.0	1.8	0.3	60
N.Y.: Onondaga Co., Syracuse, *Lewis 2184*[1]	35	33.2	2.0	0.2	34
Ohio: Summit Co., Akron, *Lewis 2303*	35	35.1	1.1	0.2	10
Penn.: Crawford Co., Kerrtown, *Lewis 2193*[1]	35	34.7	1.7	0.3	13
Texas: Collin Co., 4.5 mi. w. McKinney, *Lewis 3543*[1]	..	...	..	..	100
Va.: Montgomery Co., 1.5 mi. w. Blacksburg, *Lewis 2009*[1]	..	...	..	..	100
	318	33.4	2.3	0.1	
	Guard Cells				
var. *setigera*					
Ala.: Marshall Co., 2 mi. n. Guntersville, *Lewis 2079*[1]	25	28.6	2.3	0.5	
Mo.: New Madrid Co., 3 mi. e. Matthews, *Lewis 2350*[1]	25	30.7	3.2	0.6	
var. *tomentosa*					
Kans.: Bourbon Co., Devon, *Lewis 2382*	25	27.8	2.3	0.5	

[1] Chromosomes examined, all $2n = 14$.

six individuals had entirely abortive hips with no seed formation. Consideration of these observations with the pollen data revealed that there were plants with (1) 100 per cent abortive pollen and no fruit set, (2) 100 per cent abortive pollen and a normal amount of fruit formed, and also (3) a low percentage of abortive pollen and a normal fruit set. Undoubtedly there is some mechanism affecting this condition in *R. setigera* (perhaps genetic?) that is as yet not understood.

Guard Cells.—The measurements of guard cells were made from the living (as opposed to herbarium or dried) leaflets of three different plants. The average lengths per plant of 28.6 u, 30.7 u, and 27.8 u gave a total mean of 29.0 u (Table 2). A comparison of these results with those of all other diploid species studied (see above under pollen grains), shows that a significant difference exists in guard cell size between *R. setigera* and the diploid *Cinnamomeae* species studied (mean range of from 20.4 u to 25.5 u). On the other hand, a comparison of the guard cell measurements of the tetraploid *Cinnamomeae* species (see above) having a range of from 27.5 u to 33.0 u and a total mean length of 29.9 u, with the measurements for *R. setigera*, emphasizes the similarity here of this diploid species with the tetraploid species.

It appears that in this case, only those species closely related morphologically have their guard cell and pollen grain sizes correlated with their chromosome numbers and that the more distantly related *R. setigera*, *viz.* in a different taxonomic section, possesses a somewhat different cell size relationship with respect to chromosome number.

PHYTOGEOGRAPHY

Rosa setigera occurs in the eastern half of the United States from eastern Nebraska and Kansas, central Oklahoma and Texas to the eastern foothills of the Allegheny Mountains, and in the province of Ontario. The northern limit of distribution is western New York, southern Ontario and Michigan, and probably southern Wisconsin, although no specimens have been seen from this state. The range is continuous south to central Georgia, Alabama, and eastern Texas. Only one specimen each from Florida and Louisiana has been examined and these unfortunately lack further locality data. No collections are known from Mississippi, but these can be expected to occur at least in the northern region of the state.

On the Atlantic seaboard, *R. setigera* is well established, especially in parts of New England, the environs of Philadelphia and Washington, and eastern New York. It is quite apparent on herbarium labels from these regions that the species has been introduced by man and is

now well established, as for example: Connecticut—"large patch of rank growth, some rods from nearest house, but of course escaped"; Prince Georges Co., Maryland—"a seedling flowering as an escape in abandoned garden near Bell Sta."; Ocean Co., New Jersey—"about abandoned habitation"; or Lehigh Co., Pennsylvania—"naturalized in fields". Even though a narrow strip now exists between the species natural distribution and the eastern distribution affected by man, the expected eastern dispersal of the former and the western expansion of the latter, will undoubtedly serve to decrease this gap.

So far as recorded in Fig. 9, both varieties of *R. setigera* are found in the states of Alabama, Arkansas, Connecticut, Illinois, Indiana, Kansas, Kentucky, Michigan, Missouri, New York, Ohio, Oklahoma, Tennessee, Texas, Virginia, and West Virginia. No geographical separation of these taxa appears to be possible. The only tendency indicated is a predominance of var. *setigera* in South Carolina, Georgia, and Alabama, but unfortunately collections are few in these states. Elsewhere, var. *tomentosa* is the more frequent. The three recognized forma are found infrequently, even in states such as Missouri where collections are numerous (Fig. 10).

Selected specimens examined[1] (only one collection from each county is listed and each is recorded on Figure 9 or 10).

A. R. SETIGERA var. SETIGERA (asterisks indicate introduced specimens).

ALABAMA. De Kalb Co.: Mentone, *C. Mohr*, Sept. 1898 (US). Marshall Co.: 2 miles north of Guntersville, *W. H. Lewis 2079*. Morgan Co.: Falkville, *C. Mohr*, June 1891 (US).

ARKANSAS. Benton Co.: Siloam Springs, *D. Demaree 6903* (US). Craighead Co.: Brookland, *D. Demaree 29086* (NO, PANS). Garland Co.: Hot Springs, *E. J. Palmer 22995* (as var. *tomentosa*) (H). Newton Co.: Boxley, *D. M. Moore 32498* (ARK). Sebastian Co.: Fort Smith, *J. M. Bigelow*, 1843–4 (US). Washington Co.: near Wheeler, *E. J. Palmer 23269* (as var. *tomentosa*) (H).

CONNECTICUT. Hartford Co.: Farmington, *C. A. Weatherby*, 4 July 1896 (H)*. New London Co.: Voluntown, *C. B. Graves*, 5 July 1899 (H)*.

GEORGIA. Cobb Co.: 5 miles west of Mariette, *W. H. Lewis 2078*. Floyd Co.: Mount Berry, *H. C. Jones 279* (GA). Morgan Co.: south of Madison, *J. Bright 4908* (H). Oglethorpe Co.: 5 miles west of Philomath, *A. Cronquist 4525* (H, US). Troup Co.: Lagrange, *S. M. Tracy 9239* (H, NEB, US).

ILLINOIS. Peoria Co.: Peoria, *J. C. McDonald*, July & Oct. 1893 (H, US). Richland Co.: Gentry Creek, *R. Ridgeway 137* (H).

INDIANA. Crawford Co.: 3 miles north of Leavensworth, *C. C. Deam 16448* (H). Decatur Co.: 1 mile east of Alert, *C. C. Deam 34273* (H). Dubois Co.: St.

[1] Those citations lacking an herbarium source were collected by the author and are filed in the Stephen F. Austin State College herbarium (ASTC). Duplicates will be given to the Southern Methodist University herbarium and the Smithsonian Institute.

Anthony, *C. C. Deam 16521* (H). Harrison Co.: Palmyra, *W. H. Lewis 2415*. Jefferson Co.: 4 miles west of Madison, *C. C. Deam 16202* (H). Lagrange Co.: ¼ mile south of Brushy Prairie, *C. C. Deam 39111* (H, PH). Owen Co.: 1.5 miles east of Quincey, *C. C. Deam 34332* (H). Scott Co.: 1 mile south of Scottsburgh, *C. C. Deam 16302* (H). Switzerland Co.: 4 miles north of Vevay, *C. C. Deam 16165* (H).

KANSAS. Cherokee Co.: *A. S. Hitchcock 676* (H, US).

KENTUCKY. Edmonson Co.: Mammoth Cave Nat. Park, *H. W. Lix 351* (US). Estill Co.: Irvine, *W. A. Anderson, jr. 45* (H). Jefferson Co.: near Fern Creek, *H. Bishop et al 370* (GH). Metcalfe Co.: Edmonton, *W. H. Lewis 2340*. Muhlenberg Co.: Central City, *G. L. Fisher 16* (US). Union Co.: Morganfield, *E. J. Palmer 17833* (H).

LOUISIANA. No further data, *C. Mohr* (US).

MICHIGAN. Washtenaw Co.: Ann Arbor, *M. Dodder*, July 1931 (OKL).

MISSOURI. Greene Co.: Springfield, *S. Weller*, July 1892 (H). New Madrid Co.: 3 miles east of Matthews, *W. H. Lewis 2350*. Oregon Co.: Thomasville, *W. H. Lewis 2363*. Wright Co.: 5 miles south-west of Mansfield, *O. E. Lansing, jr. 3174* (H).

NEW YORK. Albany Co.: near Glenmont, *H. D. House 18396* (OKL)*. Chemung Co.: Elmira, *P. A. Munz 17311* (OKL)*. Madison Co.: Oneida, *W. R. Maxon 566* (US)(*?). Tompkins Co.: Ithica, *F. Coville*, 12 July 1885 (US)(*?).

OHIO. Gallia Co.: Gallipolis, *R. E. Horsey 2260* (H). Jackson Co.: Jackson, *R. E. Horsey 1742* (H). Medina Co.: Medina, *W. H. Lewis 2307*. Noble Co.: Dexter City, *W. H. Lewis 2324*. Tuscarawas Co.: 4 miles east of Newcomerstown, *W. H. Lewis 2321*.

OKLAHOMA. Haskell Co.: near Page, *G. W. Stevens 2702* (OKL). Kay Co.: 4 miles west of Kaw City, *V. Viers 36* (as *R. carolina*) (OKL). Le Flore Co.: Page, *O. W. Blakley 1460* (H, OKL, US). McCurtain Co.: 6 miles south-east of Broken Bow, *M. Hopkins & G. L. Cross 2397* (OKL). Ottawa Co.: Miami, *G. W. Stevens 2292* (H, US). Pittsburg Co.: east of Hartshorne, *O. M. Clark 2623* (OKL). Pushmataha Co.: 2 miles north-east of Kiamichi, *U. T. Waterfall 616* (OKL).

SOUTH CAROLINA. Abbeville Co.: Abbeville, *A. C. Hexamer & F. W. Maier*, 7 June 1855 (as *R. setigera* var. *glabra*) (H). Berkeley Co.: Goose Creek, *A. C. Hexamer & F. W. Maier*, 19 May 1855 (as *R. carolina*) (H)(*?).

TENNESSEE. Bedford Co.: 2 miles south-east of Shelbyville, *A. J. Sharp et al. 3702* (TENN). Coffee Co.: 4 miles south-east of Manchester, *RES et al. 9039* (TENN). Dickson Co.: Woodhaven Lake, *EHC et al. 14862* (TENN). Dyer Co.: west of Lane, *RES 15855* (as var. *tomentosa*) (TENN). Franklin Co.: Sewannee, *W. H. Lewis 2081*. Grainger Co.: Rutledge, *Brown & Kamper 9* (TENN). Hamilton Co.: near Chattanooga, *J. R. Churchill*, 3 June 1911 (H). Houston Co.: Erin, *E. J. Palmer 17615* (H). Johnson Co.: near Mountain City, *R. L. James 16692* (TENN). Knox Co.: Knoxville, *A. Ruth 276* (US). Lewis Co.: Meriwether Lewis Nat. Mon., *W. B. McDougall 1363* (US). Obion Co.: west of McConnell, *A. J. Sharp et al. 6143* (TENN). Roane Co.: White Oak Creek, *F. R. Nease 367* (DUKE, US). Sevier Co.: Gatlinburg, *G. S. Miller 2286* (US). Stewart Co.: west of Dover, *FWW et al. 13743* (TENN). Sullivan Co.: between Sulivan Gardens and Kingsport, *R. L. James 18331* (TENN).

TEXAS. Bowie Co.: near Texarkana, *E. J. Palmer 22435* (as var. *tomentosa*) (H). Camp Co.: 4 miles east of Pittsburg, *E. Whitehouse 21292* (SMU). Harrison Co.: 8¼ miles east of Karnack, *H. B. Parks & V. L. Cory 22832, 22833, 22834* (TAES). Rains Co.: Emory, *W. H. & M. E. Lewis 3548* (ASTC, SMU). Rusk Co.:

Henderson, *W. H. & M. E. Lewis 3556* (ASTC, SMU). Van Zandt Co.: 11 miles north of Edgewood, *E. Whitehouse 16444* (SMU, US). Wood Co.: Mineola, *O. Sanders 182* (SMU).

VIRGINIA. Montgomery Co.: 1.5 miles west of Blacksburg, *A. B. Massey 5037* (H).

WEST VIRGINIA. Cabell Co.: Roland Park, *F. A. Gilbert 472* (H, PENN, US). Marshall Co.: Sherrard, W. V. U. Biological Expedition, 18 June 1929 (W VA). Monongalia Co.: Morgantown, *Mr. & Mrs. H. A. Davis 5213* (W VA). Wood Co.: Ogden, *W. H. Lewis 2327*.

B. R. SETIGERA var. SETIGERA f. INERMIS.

MISSOURI. Barry Co.: near Eagle Rock, *E. J. Palmer 31439* (PH). Bollinger Co.: Patton, *E. J. Palmer 39093* (HOLOTYPE) (A). Douglas Co.: 2½–3 miles south-east of Sweden, *J. A. Steyermark 72528* (ARK). Taney Co.: Swan, *B. F. Bush 47* (H).

C. R. SETIGERA var. TOMENTOSA.

CANADA. ONTARIO. Essex Co.: Sandwich, *J. Macoun 34765* (H).

UNITED STATES. ALABAMA. Marshall Co.: 5 miles north of Guntersville, *W. H. Lewis 2080*. Mobile Co.: Mobile, *C. Mohr*, 23 April 1892 (US).

ARKANSAS. Benton Co.: 22 miles west-north-west of Rogers, *D. Demaree 6821* (OKL). Carroll Co.: Clintonville, *D. Demaree 6693* (as *R. rubifolia*) (H). Craighead Co.: Bono, *D. Demaree 3523* (ARK). Faulkner Co.: south-west of Conway, *D. M. Moore 520664* (ARK). Hempstead Co.: Fulton, *J. M. Greenman 4393* (H). Howard Co.: 1 mile north of Saratoga, *H. H. Iltis, L. Shinners, & H. Sumanth 5143* (ARK). Jefferson Co.: Hooker, *D. Demaree 21227* (H). Marion Co.: Cotter, *E. J. Palmer 5978* (US). Miller Co.: 8 miles north-east of Texarkana, *E. Whitehouse 20331* (SMU). Pike & Montgomery Co.'s: 3 miles north of Langley, *D. Demaree 9783* (H). Poinsette Co.: Harrisburg, *D. Demaree 17536* (H). Pope Co.: Hector, *G. M. Merrill 22* (H). Pulaski Co.: opposite Metropolitan Negro Pk., Little Rock, *G. M. Merrill 1250* (ARK), *1252, 2199* (H). Sharp Co.: Hardy, *D. Demaree 26859* (OKL). Yell Co.: Dardanelle, *D. Demaree 21290* (H, SMU).

CONNECTICUT. Hartford Co.: West Hartford, *C. H. Bissell*, 22 Aug. 1906 (H)*.

FLORIDA. No further locality, ex herb. *George Thurber* (H).

ILLINOIS. Cook Co.: Glencoe, *J. R. Churchill*, 1 Aug. 1926 (H). Edwards Co.: Grays, *E. J. Palmer 15564* (H). Fulton Co.: Canton, *J. Wolf*, 1875 (US). Gallatin Co.: Shawneetown, *E. J. Palmer 15490* (H). Hancock Co.: Augusta, *S. B. Mead*, 2 July 1847 (H). Island Co.: Port Bryon, *E. T. & S. A. Harper* (H). Jackson Co.: Makanda, *H. A. Gleason*, 16 July 1903 (H). Lawrence Co.: Red Hills State Park, *W. H. Lewis 2409*. La Salle Co.: near Ottawa, *E. J. Palmer 40514* (H). Macon Co.: Decatur, *I. W. Clokey 614* (H). Marion Co.: 3 miles east of Salem, *W. H. Lewis 2404*. Menard Co.: Athens, *E. Hall* (H). Peoria Co.: Peoria, *J. C. McDonald*, July – Oct. 1893 (H, US). Pope Co.: Golconda, *E. J. Palmer 15355, 25753* (H). St. Clair Co.: *H. Eggert*, 19 June 1879 (US). Tazewell Co.: Illinois River, *F. E. McDonald* (H). Union Co.: Cobden, *W. Boott*, 19 June 1861 (H). Vermilion Co.: Kickapoo State Park, *G. N. Jones 17880* (as *R. rubifolia*) (TAES).

INDIANA. Bartholomew Co.: 5 miles north-west of Columbus, *C. C. Deam 34256* (H). Boone Co.: 8 miles west of Lebanon, *C. C. Deam 17626* (H). Brown Co.: 1 mile south of Needmore, *C. C. Deam 38946* (PH). Clarke Co.: Forest Reserve, *C. C. Deam 23754* (H). Clinton Co.: 1.5 miles east of Cyclone, *C. C. Deam 34364* (H). Howard Co.: Kokomo, *C. M. Ek 15* (US). Jennings Co.: 2 miles west of Hayden, *C. C. Deam*

34203 (H). Lawrence Co.: Belt Railroad, south of Salt Creek, *R. M. Kriebel 644* (DUKE). Marion Co.: 0.8 mile west of McCordsville, *R. C. Friesner* (H). Monroe Co.: 4.5 miles north-west of Bloomington, *C. C. Deam 34311* (H). Newton Co.: 2.5 miles north-west of Kentland, *C. C. Deam 39425* (H). Owen Co.: 2 miles south-east of Spencer, *C. C. Deam 34322* (H). Putman Co.: 3 miles east of Cloverdale, *C. C. Deam 34339* (H). Tipton Co.: railroad between Goldsmith & Kempton, *C. C. Deam 13634* (H). Wells Co.: Harrison twp., *C. C. Deam*, 28 June 1903 (H).

IOWA. Story Co.: Washington twp., *A. Hayden 11526* (H).

KANSAS. Bourbon Co.: Devon, *W. H. Lewis 2382*. Cherokee Co.: Stippville, *W. H. Lewis 2375*. Crawford Co.: 2 miles south of Farlington, *W. H. Lewis 2379*. Douglas Co.: Lawrence, *W. H. Horr E146* (as *R. rubifolia*) (PENN, OKL). Labette Co.: Valeda, *E. J. Palmer 41777* (H). Linn Co.: Trading Post, *W. H. Lewis 2385*. Miami Co.: Hillsdale, *W. H. Lewis 2387*.

KENTUCKY. Ballard Co.: La Center, *W. A. Anderson*, 3 June 1933 (H). Bath Co.: Owingsville, *W. H. Lewis 2417*. Logan Co.: Russellville, *W. H. Lewis 2344*. McLean Co.: Livermore, *E. J. Palmer 17706* (H, US). Madison Co.: Richmond, *R. E. Horsey 1182* (H). Marshall Co.: Brewers, *W. H. Lewis 2348*. Rockcastle Co.: near Conway, *E. L. Brown 3118* (H). Shelby Co.: Clay Village, *W. H. Lewis 2416*.

MARYLAND. Prince Georges Co.: south of Glen Dale, *R. H. True 325* (PENN)*.

MASSACHUETTS. Berkshire Co.: Stockbridge, *R. Hoffmann*, 14 July 1919 (H)*.

MICHIGAN. Berrien Co.: vicinity of Niles, *C. K. Dodge & H. T. Darlington*, 25 Aug. 1917 (as *R. rubifolia*) (MSC). Washtenaw Co.: near Ypsilanti, *O. A. Farwell 6215* (MICH).

MISSOURI. Adair Co.: Novinger, *E. J. Palmer 25502* (H). Atchison Co.: near Watson, *E. J. Palmer 18995* (as *R. rubifolia*) (H). Bates Co.: Montieth junction, *E. J. Palmer 26066* (H). Boone Co.: Columbia, *F. Dronet 502* (H). Butler Co.: Campbell, *B. F. Bush 6307* (H). Cape Girardeau Co.: Cape Girardeau, *E. J. Palmer 17989* (H). Carroll Co.: Carrollton, *E. J. Palmer 20416* (H). Christian Co.: 4 miles east of Clever, *W. H. Lewis 2369*. Clay Co.: *B. F. Bush 12756* (as *R. rubifolia*) (H). Clinton Co.: Wallace State Park, *W. H. Lewis 2389*. Cole Co.: *B. F. Bush 12756* (as *R. rubifolia*) (H). Daviess Co.: Gallatin, *W. H. Lewis 2393;* Dent Co.: Howe's Mill, *E. J. Palmer 34946* (H, PH). Douglas Co.: Ava, *W. H. Lewis 2367*. Grundy Co.: Galt, *W. H. Lewis 2396*. Holt Co.: near Forest City, *E. J. Palmer 25403* (H). Howell Co.: 3 miles north-east of Grimmet, *W. H. Lewis 2365*. Iron Co.: near Ironton, *E. J. Palmer 18110* (as *R. rubifolia*) (H). Jackson Co.: Buckner, *B. F. Bush 12490* (as *R. rubifolia*) (DUKE, H). Jasper Co.: Fidelity, *W. H. Lewis 2374*. Johnson Co.: near Columbus, *E. J. Palmer 36657* (H). Lincoln Co.: Silex, *J. Davis*, 24 June 1912 (SMU). McDonald Co.: Noel, *E. J. Palmer 4279* (H). Macon Co.: Macon, *E. J. Palmer 35952* (H). Marion Co.: Hannibal, *J. M. Bates*, 5 July 1916 (NEB). Oregon Co.: Alton to 8 miles east, *W. H. Lewis 2361*. Ozark Co.: near Gainesville, *E. J. Palmer 34723* (H, US). Phelps Co.: Jerome, *J. H. Kellogg 367* (H). Pike Co.: Eolia, *J. Davis*, 24 June 1913 (NEB), 11 June 1911 (H). Ripley Co.: Clark Nat. Forest, Briar, *W. H. Lewis 2356*. St. Clair Co.: Osceola, *B. F. Bush 12806* (as *R. rubifolia*) (H). St. Louis Co.: North Canyon, Meramic Highlands, *M. Craig*, 27 June 1909 (H). Stoddard Co.: 3–4 miles east of Dudley, *W. H. Lewis 2352*.

NEBRASKA. Cass Co.: Weeping Water, *J. M. Bates 5127* (H, NEB). Richardson Co.: Missouri River, *H. J. Webber 271* (US), *5107* (NEB).

NEW HAMPSHIRE. Cheshire Co.: Keene, *E. J. C. Gilbert*, June 1889 (PH)*.

NEW JERSEY. Ocean Co.: Manahawkin, *B. Long 27805* (H, PH)*.

NEW YORK. Erie Co.: Collins, *A. E. Perkins*, 24 July 1927 (H). Onandaga Co.:

Syracuse, *W. H. Lewis 2184**. Oneida Co.: east of Oneida, *H. D. House 6446* (H). Thompkins Co.: Ithaca, *A. J. Eames 8326* (H) (*?).

NORTH CAROLINA. Buncombe Co.: Swannonoa River, near Biltmore, *Biltmore herb. 1320b* (H, PENN).

OHIO. Champaign Co.: Thackery, *E. C. Leonard*, 1 July 1914 (US). Clinton Co.: south-west of Wilmington, *E. B. Harger 8101* (H). Greene Co.: Xenia, *H. A. Young*, 10 July 1883 (H). Hardin Co.: Kenton, *R. E. Horsey 742* (H). Lorain Co.: Oberlin, *A. E. Richsecker*, 29 June 1895 (US). Miami Co.: Piqua, *E. J. Palmer 43616* (US). Richland Co.: Mansfield, *E. Wilkinson*, 7 July 1895 (OKL). Summit Co.: Akron, *W. H. Lewis 2303*.

OKLAHOMA. Atoka Co.: north of Atoka, *G. T. Robbins 2563* (OKL). Bryan Co.: Bennington, *E. J. Palmer 10440* (H). Carter Co.: 5 miles north-east of Ardmore, *L. L. Penny 85* (OKL). Cherokee Co.: east of Mount Gibson, *R. Bebb 4206* (as *R. cherokeensis*) (OKL). Choctaw Co.: Hugo, *E. J. Palmer 9021* (H). Cleveland Co.: *H. A. Hawk 10* (OKL). Coal Co.: 10⅔ miles north-north-west of Coalgate, *V. L. Cory 56293* (SMU). Haskell Co.: Stigler, *B. Osborn 413R* (H). Johnston Co.: 5.2 miles south-east Tishomingo, *V. L. Cory 58880* (SMU). McCurtain Co.: south of Haworth, *A. & R. Nelson, & G. J. Goodman 5401* (OKL). Marshall Co.: east of UOBS, *P. B. Riggs*, 15 June 1952 (SMU). Mayes Co.: 3 miles north-east of Locust Grove, *C. S. Wallis 4067* (SMU). Murray Co.: Sulphur, *G. M. Merrill 1639* (H). Muskogee Co.: Muskogee, *R. Bebb 5966* (as *R. cherokeensis*) (OKL). Ottawa Co.: Miami, *G. W. Stevens 2292* (OKL). Pontotoc Co.: 3–4 miles south-east of Fittstown, *G. T. Robbins 2549* (OKL). Pottawatomie Co.: near Shawnee, *B. Osborn 1599R* (H). Seminole Co.: 3 miles south of Maud, *M. Faulkner 128* (OKL). Sequoyah Co.: 5.4 miles north-east of Gore, *C. S. Wallis 3988* (SMU).

PENNSYLVANIA. Crawford Co.: Kerrtown, *W. H. Lewis 2193*. Delaware Co.: ¼ mile south-west of Pleasant Hill, *C. I. Stiteler*, 28 June 1951 (PH)*. Lehigh Co.: 2.5 miles south-east of Alburtis, *R. L. Schaeffer 32935* (PH)*. Monroe Co.: Shawnee on Delaware, *S. L. Glowenke*, 29 June 1936 (H)*.

TENNESSEE. Blount Co.: Rich Mountain, *LRH & AJS 1682* (as *R. rubifolia*) (TENN). Davidson Co.: Nashville, *A. Gattinger 9a* (H). Dyer Co.: north of Ro Elen, *A. J. Sharp et al. 6297* (TENN). Gibson Co.: north-west of Trenton, *L. Nicholson et al. 17767* (TENN). Grainger Co.: Lea Lakes, *AJS & LRH 1593* (as *R. rubifolia*) (TENN). Hickman Co.: below Beaver Dam Springs, *A. J. Sharp et al. 47–459* (TENN). Knox Co.: Knoxville & vicinity, *C. S. Sargent*, 20 Sept. 1885 (H). Obion Co.: 1.5 miles east of Clayton, *D. E. & M. S. Eyles 8394* (as *R. rubifolia*) (H). Rutherford Co.: 12.3 miles south of Murfreesboro, *L. Hubricht B2150* (TENN). Sullivan Co.: between Sullivan Gardens – Kingsport, *R. L. James 18331* (TENN). Union Co.: Norris Lake Forest, *A. Morrison, 15 June 1937* (TENN).

TEXAS. Bowie Co.: 6 miles west of Texarkana, *E. Whitehouse 20121* (as *R. rubifolia*) (SMU). Collin Co.: 4.5 miles west of McKinney, *W. H. & M. E. Lewis 3543* (ASTC, SMU). Dallas Co.: Dallas, *M. Stephenson*, 23 Aug. 1928, 28 May 1929 (US). Fannin Co.: 2¾ miles south-east of Bonham, *V. L. Cory 54687* (GA, SMU). Grayson Co.: Denison, *E. J. Palmer 12614, 14272* (H, US). Gregg Co.: 2 miles south of Gladewater, *W. H. & M. E. Lewis 3554* (ASTC, SMU), Harrison Co.: Marshall, *E. J. Palmer 7914* (H). Henderson Co.: 2⅔ miles south-east of Eustace, *V. L. Cory 53896* (SMU). Hopkins Co.: Sulphur Springs, *L. H. Shinners 15036* (SMU). Hunt Co.: 3 miles south-east of Greenville, *W. H. & M. E. Lewis 3545* (ASTC, SMU). Lamar Co.: ⅓ mile east of Chicotah, *V. L. Cory 54670* (GA, SMU). Morris Co.: 8 miles south of Daingerfield, *V. L. Cory 25693* (as *R. Woodsii*)

(H). Nacogdoches Co.: *H. B. Parks*, 19 May 1936 (ASTC). Rains Co.: 1.9 miles north-west of Point, *W. H. & M. E. Lewis 3547* (ASTC, SMU). Red River Co.: 7.5 miles north-east of Clarksville, *R. McVaugh 7188* (SMU). Rockwall Co.: 3.5 miles south-west of Rockwall, *V. L. Cory 52318* (SMU, TAES, US). Rusk Co.: Henderson, *W. H. & M. E. Lewis 3557* (ASTC, SMU). Smith Co.: Beauchamp Springs, Tyler St. Pk., *V. L. Cory 56909* (SMU, US). Titus Co.: 3 miles north of Mount Pleasant, *L. H. Shinners 16099* (SMU, TAES). Upshur Co.: Rosewood, *W. H. & M. E. Lewis 3551* (ASTC, SMU). Wood Co.: 4.5 miles west of Quitman, *W. H. & M. E. Lewis 3550* (ASTC, SMU). Van Zandt Co.: 2.5 miles south-east of Ben Wheeler, *R. Kral 1027* (FSU).

VIRGINIA. Fauquier Co.: near Hopewall Gap, Bull Run Mts., *H. A. Allard 7804* (H)*. Montgomery Co.: 1.5 miles west of Blacksburg, *W. H. Lewis 2009*.

WEST VIRGINIA. Cabell Co.: Huntington, *F. A. Gilbert 125* (WVA). Jackson Co.: near Fair grounds, *W. V. U. Botanical Expedition*, 24 June 1930 (WVA), 28 June 1930 (H). Tyler Co.: Middleborne, *W. V. U. Biological Expedition*, 16 June 1931 (WVA). Upshur Co.: Buckhannon, *C. F. Millspaugh 395* (WVA). Wayne Co.: Buffalo Creek, *L. Plymale* 26 (WVA).

D. R. SETIGERA var. TOMENTOSA f. SERENA.

ARKANSAS. Baxter Co.: Cotter, *E. J. Palmer 26216* (as *R. setigera* var. *serena*) (OKL). Marion Co.: Bull Shoals, *D. Demaree 30180* (as *R. setigera*) (DUKE, US). Randolph Co.: Ravenden Springs, *D. Demaree 29186* (as *R. setigera*) (OKL).

IOWA. Louisa Co.: near Columbus junction, *A. Hayden 9180* (as *R. setigera* var. *serena*) (US).

MISSOURI. Crawford Co.: 1 mile west of Butts, *J. A. Steyermark 41294* (as *R. setigera* var. *serena*) (US). Ozark Co.: near Tecumseh, *E. J. Palmer 32902* (as *R. setigera*) (H). Taney Co.: Branson, *E. J. Palmer 5897* (as *R. setigera*) (US).

OKLAHOMA. Latimer Co.: 25 miles east of McAlester, *J. C. Shirley* (H). Muskogee Co.: Braggs Hill road, *R. Bebb 4967* (as *R. cherokeensis*) (OKL).

E. R. SETIGERA var. TOMENTOSA f. ALBA.

MISSOURI. Howell Co.: 7 miles south of West Plains, *J. A. Steyermark 78797* (as *R. setigera* f. *alba*) (SMU). Reynolds Co.: 4 miles southeast of Bunker, *J. A. Steyermark 72011* (HOLOTYPE) (F).

ECOLOGY: TRANSPLANT EXPERIMENT

A detailed morphological study of several plants as collected in the field was followed by a similar study over several years after the specimens had been moved to an arboretum plot (Blandy Experimental Farm in northern Virginia). One of these plants collected 1.5 miles west of Blacksburg, Virginia (*Lewis 2009*) was studied in 1953 (original), and later in 1955 and 1956 (at Blandy). Leaflet width and length measurements (of 5 apical leaflets each year) were greater in 1953 (28 mm. and 57 mm.) than in 1955 (27 mm. and 55 mm.) or 1956 (24 mm. and 43 mm.), although the ratio of leaflet width to length was not appreciably altered. A change from the shaded, moist, roadside microenvironment to an exposed, often dry, experimental plot was probably one factor contributing to a decrease in leaflet area.

In addition, year to year fluctuations in climate as well as varying conditions within a single growing season undoubtedly contributed to such modifications.

No appreciable differences were noted between the sepal width and length, auricle width, pedicel length, or number of serrations per half leaflet for these years. The number of flowers per inflorescence, however, was often greatly modified. The 1953 inflorescence for *Lewis 2009* contained a maximum of four flowers, while in 1955 and 1956, as many as ten flowers in an inflorescence were observed each year. This increase in flower number was apparent for all plants moved to the experimental plot (*Lewis 2079*, Ala.; *Lewis 2184*, N. Y.; *Lewis 2348*, Ky., and others). The transplanted specimens were further modified by the addition of petiole bristles, if not previously present, and by an increase in the amount of petiole pubescence and number of glands. The type of leaflet serration was also altered from either a biserrate or partly biserrate margin to a partly biserrate or simple serration, respectively. No noticeable change in either the absence or presence of leaflet pubescence or glands, sepal pubescence, glands, or bristles, pedicel glands, auricle glands, or hypanthium glands, was noted.

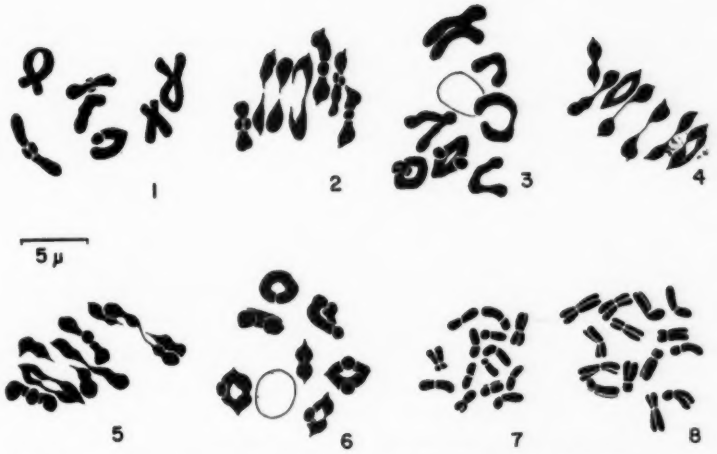
There would seem to be little doubt that the modifications of a number of character expressions for this species is traceable, partially at least, to environmental conditions.

CYTOLOGY

Two plants of *R. setigera* were examined cytologically by Täckholm (1922), who found the somatic number of fourteen. Although the regular formation of seven bivalents was predominant in PMC's, Täckholm did observe an occasional metaphase I with six bivalents and two univalents. Since he was unable to observe this condition affecting the later formation of gametes, he assumed that each univalent had gone to a respective pole. Both Hurst (1928) and Flory (1950) confirmed the somatic number. Erlanson (1929) found only regular meiosis (7 bivalents).

Of nine plants in which PMC meiosis was examined, 65 cells at meiosis I and II illustrated only complete regularity. Figures 1 through 6 are such examples of regular diakinesis and metaphase I from six individuals collected in a number of states. These and other plants are listed with their original localities in Table 3.

Immature leaflet tissue was exained for seven plants; all cells were regular with 14 somatic chromosomes (for example, Figures 7 and 8).



Figs. 1–8. Chromosomes of *R. setigera*—Fig. 1: var. *setigera* (Lewis 2079), PMC late diakinesis, 7 II. Fig. 2: var. *tomentosa* (Lewis 2387), PMC metaphase I, 7 II. Fig. 3: var. *setigera* (Lewis 2340), PMC diakinesis, 7 II. Fig. 4: var. *tomentosa* (Lewis 2417), PMC metaphase I, 7 II. Fig. 5: var. *tomentosa* (Lewis 2393), PMC metaphase I, 7 II. Fig. 6: var. *setigera* (Lewis 2321), PMC diakinesis, 7 II. Fig. 7: var. *tomentosa* (Lewis 2375), leaf metaphase, 2n=14. Fig. 8: var: *tomentosa* (Lewis 2356), leaf metaphase, 2n=14. Drawings with camera lucida at x4200, here reduced by ca. ½ in reproduction.

Five cells from each of four plants indicate the following karyotype:

2 pairs long submedian chromosomes (bb, bb)
1 pair long subterminal chromosomes (cc)
2 pairs medium submedian chromosomes (ee, ee)
2 pairs medium subterminal chromosomes (ff, ff).

This chromosome morphology is different from that of any other diploid species examined(i.e., east of the Rocky Mountains). Not only are gross- and micro-morphological characters for *R. setigera* strikingly diverse from other diploid species in eastern North America. but chromosome morphology as well.

Of further interest is the larger size of the *R. setigera* chromosomes as compared with those of all other species studied. The longest chromosomes of this taxon are approximately 5 u in length while the longest of the other species rarely exceed 3u. This increase in chromatin is probably associated with the greater cell size (see Micromorphology) encountered for this species as compared with other diploid taxa of the section *Cinnamomeae*.

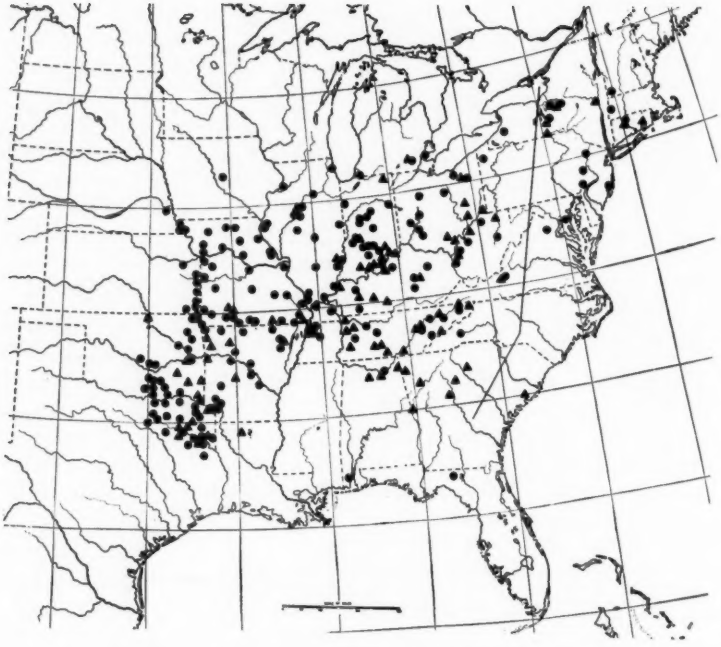


Fig. 9. The distribution of *R. setigera* as listed under Selected Specimens Examined. Triangles represent var. *setigera*, circles represent var. *tomentosa*.

TAXONOMY

Rosa setigera is divisible into two main taxa according to: (1) the absence of leaflet pubescence below except on the veins, var. *setigera*; or (2) the presence of leaflet pubescence, var. *tomentosa* T. & G. Several forma are recognized: *R. setigera* var. *setigera* f. *inermis* Palmer & Steyerm., *R. setigera* var. *tomentosa* f. *serena* (Palmer & Steyerm.) Fern., and *R. setigera* var. *tomentosa* f. *alba* Steyerm.

Key.

a. Leaflets glabrous below or with pubescence on veins only
  b. Floral stems armed — var. *setigera*
  bb. Floral stems unarmed — var. *setigera* f. *inermis*
aa. Leaflets pubescent below
  b. Petals pink

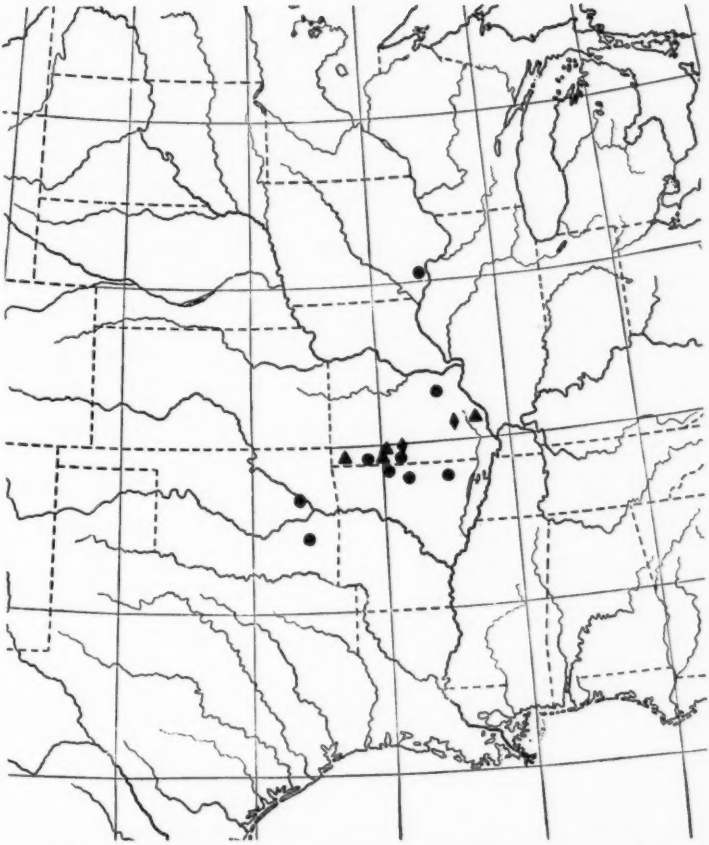


Fig. 10. The distribution of three forma of *R. setigera*: triangles represent var. *setigera* f. *inermis*, circles represent var. *tomentosa* f. *serena*, diamonds represent var. *tomentosa* f. *alba*.

c.	Floral stems armed	var. *tomentosa*
cc.	Floral stems unarmed	var. *tomentosa* f. *serena*
bb.	Petals white	var. *tomentosa* f. *alba*

Description (based on 100 individuals).

Stems climbing or trailing, 2–5 m. long, armed with scattered and infrastipular curved thorns to the apex of the floral branches (90%), or with infrastipular curved thorns only (10%), occasionally hispid, rarely unarmed (in f. *inermis* and f. *serena*); leaves 3–5 foliolate;

TABLE 3

Chromosome Numbers Reported for *Rosa setigera*

Locality and collection	n	2n	Fig.	Author
No. 20 and No. 21	7	14	..	Tackholm (1922)
"North America"	.	14	..	Hurst (1928)
"Ohio"	7	..	..	Erlanson (1929)
"Eastern & central North America"	.	14	..	Flory (1950)
Ala.: Marshall Co., 2 mi. n. Guntersville, *Lewis 2079*[1]	7	..	x	Lewis
Ill.: Lawrence Co., Red Hills State Park, *Lewis 2409*	7	..	..	Lewis
Kans.: Cherokee Co., Stippville, *Lewis 2375*	.	14	x	Lewis
Kans.: Miami Co., Hillsdale, *Lewis 2387*	7	..	x	Lewis
Ky.: Bath Co., Owingsville, *Lewis 2417*	7	..	x	Lewis
Ky.: Metcalfe Co., Edmonton, *Lewis 2340*[1]	7	..	x	Lewis
Mo.: Daviess Co., Gallatin, *Lewis 2393*	7	..	x	Lewis
Mo.: New Madrid Co., 3 mi. e. Matthews, *Lewis 2350*[1]	7	..	x	Lewis
Mo.: Ripley Co., Briar, *Lewis 2356*	.	14	x	Lewis
N.Y.: Onondaga Co., Syracuse, *Lewis 2184*	.	14	..	Lewis
Ohio: Medina Co., Medina, *Lewis 2307*[1]	.	14	..	Lewis
Ohio: Tuscarawas Co., 4 mi. e. Newcomerstown, *Lewis 2321*[1]	7	..	x	Lewis
Penn.: Crawford Co., Kerrtown, *Lewis 2193*	.	14	..	Lewis
Texas: Collin Co., 4.5 mi. w. McKinney, *Lewis 3543*	.	14	..	Lewis
Va.: Montgomery Co., 1.5 mi. w. Blacksburg, *Lewis 2009*	.	14	..	Lewis

[1] *R. setigera* var. *setigera*; the remaining specimens are *R. setigera* var. *tomen-*

leaflets ovate or acute, rounded at the base and often acuminate at the apex, $\bar{x}=27.2$ ($s=7.7$) mm. in width, $\bar{x}=47.8$ ($s=12.0$) mm. in length, ratio of leaflet width to length, $\bar{x}=0.57$ ($s=0.06$), glabrous above (98%) or rarely pubescent (2%), glabrous below although often pubescent on the veins (29% in var. *setigera*), puberulent, pubescent, or tomentose below (71% in var. *tomentosa*), eglandular (97%) or slightly glandular below (3%), serration number per half leaflet $\bar{x}=37$ ($s=8.5$), singly serrate (59%), singly and biserrate (17%), or biserrate (24%), the serrations often obtuse, not gland-tipped (18%) or with glands (82%); petioles without bristles (4%) or typically with bristles (96%), often extending along the mid-vein

of the leaflet, glandular and often extending along the mid-vein, glabrous (20%) or pubescent (80%); stipules adnate, rarely eglandular (1%) or commonly glandular (99%) on the margin and abaxial surface, with one auricle $\bar{x}=3.2$ ($s=0.8$) mm. in length; inflorescence usually corymbose, 1–15 flowered ($\bar{x}=6$, $s=3.1$); pedicels $\bar{x}=14.2$ ($s=4.6$) mm. in length, glandular, often deciduous with age, glabrous (90%) or somewhat pubescent (10%); sepals $\bar{x}=2.7$ ($s=0.5$) mm. wide at the base, $\bar{x}=12.2$ ($s=1.8$) mm. long, glandular-hispid, pubescent on the outside, tomentose within, without bristles; petals pink, white, or intermediate, obcordate; styles exserted, united; hypanthium globose or rounded-ellipsoid, glandular-hispid, the glands and stalks often deciduous with age; pollen grains $\bar{x}=33.4$ ($s=2.3$) u in diameter; guard cells $\bar{x}=29.7$ u in length; chromosome number $2n=14$.

Synonymy.

A. *Rosa setigera* Michx. var. *setigera*, Fl. Bor.-Am. 1: 295 (1803).
R. carolina L. (1762), Walter Fl. Carol. 149 (1788) pro parte.
R. setigera Michx. var. *elatior* Pers., Syn. Plant. 2: 48 (1806).
R. fenestrata Donn, Hort. Cantab., ed. 7 ,154 (1812)—name only; Tratt., Rosac. Mon. 2: 187 (1823).
R. rubifolia Ait. f. var. *fenestralis* Lindl., Ros. Mon. 125, t. 15 (1820).
R. setigera Michx. var. *pubescens* Raf., Ann. Gen. Sci. Phys. 5: 213 (1820).
R. trifoliata Raf., Ann. Gen. Sci. Phys. 5: 213 (1820).
R. setigera Michx. var. *glabra* Torrey & Gray, Fl. N. Am. 1: 458 (1840).
R. rubeae At., Ark. f. Bot. 16 (9): 19 (1920) pro parte.

Holoytpe. "Georgie", Michaux (H. photograph).

B. *Rosa setigera* Michx. var. *setigera* f. *inermis* Palmer & Steyerm., Ann. Mo. Bot. Gard. 22: 569 (1935).

Holoytpe. Patton, Bollinger Co., Missouri, E. J. Palmer 39093 (A).

C. *Rosa setigera* Michx. var. *tomentosa* Torrey & Gray, Fl. N. Am. 1: 457 (1840).
R. rubifolia Ait. f. in Ait., Hort. Kew., ed. 2, 3: 260 (1811).
R. kentukensis Raf., Ann. Gen. Sci. Physi. 5: 213 (1820).
R. cursor Raf., Ann. Gen. Sci. Phys. 5: 215 (1820).
R. mutabilis Bradb. (non Courset 1811) in James, Account Long's Exp. Rocky Mts. 1: 69 (1823).
R. rubifolia Ait. f. var. *macrophylla* Ser. in DC., Prod. 2: 599 (1825).

? *R. laevigata* Borrer (non Michx. 1803) in Hook., Fl. Bor.Am. 1: 200 (1832).

R. rubeae At., Ark. f. Bot. 16 (9): 19 (1920) pro parte.

D. *Rosa setigera* Michx. var. *tomentosa* T. & G. f. *serena* (Palmer & Steyerm.) Fern., Rhod. 50: 145 (1948).

R. setigera Michx. var. *serena* Palmer & Steyerm., Ann. Mo. Bot. Gard. 22: 569 (1935).

E. *Rosa setigera* Michx. var. *tomentosa* T. & G. f. *alba* Steyerm. Rhod. 54: 254 (1952). *Holotype*. 4 miles southeast of Bunker, Reynolds Co., Missouri, *J. A. Steyermark 72011* (F).

From a cross of *R. setigera* var. *setigera* and *R. setigera* var. *tomentosa* (*Erlanson 11790*), Erlanson found (personal letter of 26 October 1956) all four progeny with pubescent leaflets. Of the 300 individuals examined in the present study for the expression of the leaflet surface below, 70 per cent were found to have pubescent leaflets (36% puberulent and 34% pubescent) while the remaining 30 per cent were glabrous including the pubescent veined variation. Of these, 10 per cent had completely glabrous leaflets. It will be recalled that in the transplant experiments, leaflets of no plant were modified from pubescent to glabrous ,or vice versa, by a change of environment. It is presumed that the various expressions are not due primarily to the environment, but rather to some other factor.

From the above discussion, it seems probable that this 'character' is controlled by two, or perhaps more, pairs of alleles giving at least four possible phenotypic expressions in the F_2 and succeeding generations. One further expression, that of tomentose leaflets, is undoubtedly present in the population, but no record of its occurrence was possible (as explained earlier). The results of Erlanson's work coupled with the present population study could fit an interpretation as follows:

Parents		$P_1P_1P_2P_2$ x $p_1p_1p_2p_2$	
		tomentose glabrous	
F_1		$P_1p_1P_2p_2$	
		puberulent	
F_2, F_3 etc.		*Genotype*	*Phenotype*
	1	$P_1P_1P_2P_2$	tomentose
	2	$P_1P_1P_2p_2$	pubescent
	2	$P_1p_1P_2P_2$	pubescent
	4	$P_1p_1P_2p_2$	puberulent
	1	$P_1P_1p_2p_2$	puberulent
	1	$p_1p_1P_2P_2$	puberulent
	2	$P_1p_1p_2p_2$	glabrous, but veins puberulent

2	$p_1p_1P_2p_2$	glabrous, but veins puberulent
1	$p_1p_1p_2p_2$	glabrous

A summary of the actual and expected results is given in Table 4. There seems from these data to be a real association between the taxonomic separation into var. *tomentosa* (pubescent) represented by three phenotypes or 70 per cent of the population and var. *setigera* (glabrous) represented by two phenotypes or 30 per cent of the population.

TABLE 4

Expression on Leaflet Surface Below in *Rosa setigera*

	var. *setigera*		var. *tomentosa*		
	Glabrous	Glabrous but Puberulent veins	Puberulent	Pubescent	Tomentose
Actual no.	30	60	108	102	....
Expected no.	18	75	114	75	18
Total actual no.		90		210	
Total expected no.		93		207	
$X^2 = 0.14$; $p = 0.7$					

ACKNOWLEDGMENTS

I wish to thank the many curators of herbaria who have generously loaned me material from their collections. To Dr. W. S. Flory, Jr., Blandy Experimental Farm, University of Virginia, for his guidance during the course of this study and review of the manuscript, I give my sincere appreciation.

LITERATURE CITED

AITON, W. T. (*fil.*). 1811. *Rosa*, in W. Aiton, Hortus Kewensis. Vol. 3. London.

ERLANSON, E. W. 1929. Cytological conditions and evidences for hybridity in North American wild roses. Bot. Gaz. 87: 443–506.

————. 1934. Pollen analysis for rose-breeders. Am. Rose Ann. (1934): 63–68.

FERNALD, M. L. 1948. Some minor forms of *Rosa*. Rhodora 50: 145–147.

LEWIS, W. H. 1957. An introduction to the genus *Rosa* with special reference to *R. acicularis*. Va. J. Sci. 8: 197–202.

————. 1959a. Rosa setigera f. alba a form of var. tomentosa. Southewestern Nat. 3: 214.

————. 1959b. A monograph of the genus *Rosa* in North America. I. *R. acicularis*. *Brittonia* 11: 1–24.

LINDLEY, J. 1820. Rosarum Monographia. London. 156 pp.

PALMER, E. J. and J. A. STEYERMARK. 1935. An annotated catalogue of the flowering plants of Missouri. Ann. Mo. Bot. Gard. 22: 375–558.

PERSOON, C. H. 1806. Synopsis Plantarum seu Enchiridium Botanicum. Vol. 2. Paris.

RYDBERG, P. A. 1918. North American Flora. Vol. 22. Part 6.

TACKHOLM, G. 1922. Zytologische studien über die gattung *Rosa*. Act. Hort. Berg. 7: 97–381.

TORREY, J. and A. GRAY. 1840. Flora of North America. Vol. 1. New York. 711 pp.

WALTER, T. 1788. Flora Caroliniana. London.

THE SOUTHWESTERN NATURALIST 3: 175–203 1958 (PRINTED 1959)

THE TEXAS SPECIES OF CROTON (EUPHORBIACEAE)

MARSHALL C. JOHNSTON

Sul Ross State College, Alpine, Texas

ABSTRACT. Key and principal synonymy are given for the 18 accepted Texas species of *Croton*, and maps are provided to show Texas distribution as indicated by herbarium specimens in several institutions. The species include *C. glandulosus* L. (3 varieties in Texas: var. *septentrionalis* Muell. Arg., var. *Lindheimeri* Muell. Arg., and var. *pubentissimus* Croizat); *C. monanthogynus* Michx.; *C. leucophyllus* Muell. Arg. var. *leucophyllus*, incl. *C. Palmeri* S. Wats. (the Mexican variety *trisepalis* Ferguson is also mentioned); *C. corymbulosus* Engelm. (var. *corymbulosus*, and var. **thermophilus,** new variety); *C. Lindheimerianus* Scheele (var. *Lindheimerianus*, and var. **Tharpii,** new variety); *C. capitatus* Michx. (var. *capitatus*, var. *Lindheimeri* (Engelm. & Gray) Muell. Arg., and var. *albinoides* (Ferguson) Shinners, incl. *C. Muelleri* Coulter); *C. Coryi* Croizat; *C. punctatus* Jacq.; *C. dioicus* Cav. (incl. *C. neomexicanus* Muell. Arg.); *C. texensis* (Klotzsch) Muell. Arg.; *C. Parksii* Croizat; *C. argyranthemus* Michx.; *C. ciliatoglandulosus* Ort.; *C. humilis* L.; *C. Torreyanus* Muell. Arg.; *C. suaveolens* Torr.; *C. Cortesianus* H.B.K.; *C. fruticulosus* Engelm.; lectotypes are designated for several of these names.

Croton is a genus of more than 600 species of herbs, shrubs, and trees in warm regions of the world. Perhaps 25 species occur in the United States, staying mainly to the southern states. Texas has 18 of these species, being the richest, in this regard, of the states.

The treatment of United States Crotons by Ferguson (1901, repeated largely in Small, 1903) is remarkably well-done. Fortunately most of the original collections of our southwestern species are represented in American herbaria. With vastly greater herbarium stores, opportunities for field study, and full use of a type method, we should now have the basis for a more nearly satisfactory treatment.

The following synopsis is based on study of the Crotons at the herbaria of the University of Texas, Southern Methodist University, Sul Ross State College, the United States National Herbarium, and the Academy of Natural Sciences of Philadelphia, and of selected specimens from Gray Herbarium-Arnold Arboretum, and the University of Michigan, and casual examination of the Crotons at the Instituto de Biología at Chapultepec and the University of California at Berkeley. To the staffs of those herbaria I am grateful for their kindnesses, especially to Dr. C. E. Kobuski, Dr. Lyman B. Smith, and Dr. Lloyd H. Shinners. I am especially grateful to Dr. B. C. Tharp of the University of Texas for his interest.

Crotons in the United States are not of much economic importance. Like most aromatic plants, some of our species have been assigned various medicinal properties; I can find no evidence that any of these properties has been demonstrated. The seeds of several Crotons are important food for Mourning and White-winged doves, and for quail. *Croton capitatus* Michx., *Croton texensis* (Klotzsch) Muell. Arg., and *Croton monanthogynus* Michx. are reported to be poisonous to livestock when eaten (Boughton, 1931; Wheeler in Kearney & Peebles, 1951: 504; Gates, 1941: 143, 145, 192). Gates (l.c.) reports that *Croton texensis* causes most Croton poisoning, apparently because stock animals will eat it fairly freely in comparison with any other, and that *Croton capitatus* "owing to the bitter taste" is not consumed "except under conditions of dire necessity." In west-central Texas, I have had *Croton Lindheimerianus* Scheele pointed out by a rancher as a weed which sheep will eat. Of *Croton monanthogynus*, Deam (1940: 638) says that stock will not eat it, and Gates (1941: 192) says it is poisonous, eaten only when "desirable herbage is scarce, as under extreme conditions of drought." Over large areas of sandy ranges of coastal southern Texas, for the most part badly overgrazed by cattle, two robust annuals, *Croton Parksii* Croizat (closely related to the poisonous *C. texensis*) and *Croton capitatus* var. *albinoides* (Ferguson) Shinners, assume aspect dominance in late summer and fall. Dr. Barton H. Warnock of Sul Ross State College tells me that an abundance of *C. corymbulosus* Engelm. can be taken as an indication of over-use of range in trans-Pecos Texas.

I offer below keys to the Texas species of *Croton*, with no special attempt to show relationships, but with a special attempt to use characters which are easily seen. Since at least three of our annual Crotons were described as perennials, I assume that the annual versus perennial distinction is difficult, and have not made use of it. Likewise, the shrubby versus suffrutescent habit is not used. Since specimens of at least 10 of the species often appear to be exclusively staminate, I append a key to those species, based almost entirely on foliage characters. This key is not as satisfactory as the first key, since the variability in some of the foliage characters is greater than in the flower parts. "Lower leaves," as used in the keys, means the oldest leaves on herbarium specimens.

KEY TO MATERIAL BEARING SOME PISTILLATE FLOWERS

(1) Styles only once dichotomous, giving 6 ultimate stigmatal ends per flower (or only 4 in No. 2) ..... (2)

(2) Leaves distinctly serrate; a minute gland present on each side of the base of the midvein on the lower surface of the blade; lower petioles usually less than half as long as the blades they support .....1. *C. glandulosus* L. varieties

(2) Leaves not serrate (sometimes appearing very minutely serrate in Nos. 15, 17, and 18); blades not biglandular below at base .....(3)

(3) Petioles of lower leaves usually at least half as long as the blades they support (often as long as the blades in Nos. 3 and 5) .....(4)

(4) Styles 2, ultimate stigmatal ends 4 per flower; mature capsule 1-seeded .....2. *C. monanthogynus* Michx.

(4) Styles 3, ultimate stigmatal ends 6 per flower; mature capsule 3-seeded .....(5)

(5) Pistillate calyxes not actinomorphic; 3 lobes well-developed, 2 lobes weak or suppressed.....3. *C. leucophyllus* Muell. Arg.

(5) Pistillate calyxes with 5 equal or subequal lobes (in No. 5 rarely only 4 lobes are well-developed) .....(6)

(6) Mature pistillate calyxes about half as long as the fruit; stamens and styles usually at least 1 mm. long; collections usually fragmentary, broken near ground level, but the lower part usually obviously ligenous and perennial .....4. *C. corymbulosus* Engelm.

(6) Mature pistillate calyxes at least three-quarters and usually fully as long as the fruit; stamens and styles usually about 1 mm. long, rarely more than 1.5 mm. long; collections often of complete plants, showing annual tap-roots .....5. *C. Lindheimerianus* Scheele

(3) Petioles of most leaves less than a third as long as the blades they support; collections almost always fragmentary, of outer branches of shrubby plants.....(7)

(7) Leaf-blades oblong (most of them well more than twice as long as broad, tomentose beneath, above

short-pubescent and not tomentose).....
.....15. *C. Torreyanus* Muell. Arg.

(7) Leaf-blades tapering from near the middle to the apex .....(8)

(8) Leaf-blades widest near the middle, tapering to a pointed apex and to a pointed or shortly rounded base, rarely with cordate tendencies .....(9)

(9) Leaf-blades thick, rough tomentose on both sides; about twice as long as wide .....16. *C. suaveolens* Torr.

(9) Leaf-blades not thick, with a smooth, short grayish tomentum beneath, but green and glabrous or with only a light, non-tomentose pubescence above, usually more than twice as long as broad .....17. *C. Cortesianus* H.B.K.

(8) Leaf-blades ovate, tapering from near the base to the apex, often shallowly cordate at base (tomentose on both surfaces, but less densely so above, usually about twice as long as broad) .....18. *C. fruticulosus* Engelm.

(1) Styles more than once dichotomous (in No. 12 each style appears trifid or quadrifid), giving usually at least 10 ultimate stigmatal branches per flower .....(10)

(10) Pistillate calyxes, or most of them, having at least 6 lobes, usually 6 to 9 .....(11)

(11) Leaves pinnate-nerved, the lateral nerves of the lower surface curving, not parallel, most of them prominent; petals of staminate flowers not conspicuous .....6. *C. capitatus* Michx.

(11) Leaves pinnate-nerved, the lateral nerves of the lower surface straight and rather strictly parallel, not raised above the tomentum; staminate flowers with 5 conspicuous silvery scaly petals ....7. *C. Coryi* Croizat

(10) Pistillate calyxes 5-lobed (in No. 12 a few of them 6-lobed) .....(12)

(12) Most petioles at least half as long as the blades they support .....(13)

(13) Most styles 1 to 2 mm. long, the ends not spreading; blades rotund, rounded at apex, or if pointed

the angle greater than 100° 8. *C. punctatus* Jacq.

(13) Most styles 3 to 5 mm. long, the ends tending to spread; blades tapered from near the middle to the pointed acute apex, which forms a 40–70° angle .....(14)

(14) Stipules and margins of leaves conspicuously glandular-ciliate .....
.....13 *C. ciliatoglandulosus* Ort. Ort.

(14) Stipular and foliar glandular ciliation, when present, not noticeable without a lens ..... 14. *C. humilis* L.

(12) Most petioles less than half as long as the blades they support .....(15)

(15) Styles 2 to 4 mm. long (usually 3 mm.), relatively slender, near their midpoints appearing trifid or quadrifid; leaves and stems conspicuously silvery scaly, brightest on the underside of the leaves; staminate and pistillate flowers appearing on the same plant .....
.....12. *C. argyranthemus* Michx.

(15) Styles at most 3 mm. long (usually 2 mm.), relatively thick and squat, the first dichotomy being near the base; leaves, when scaly, not brightly so; staminate flowers never occurring on same plant as pistillate flowers .....(16)

(16) Leaves scaly silvery canescent beneath, dark gravish above; base of plant usually manifestly ligneous with several stems (perennial, but flowering first year) .....
.....9. *C. dioicus* Cav.

(16) Leaves green, yellowish-green, or yellowish-gray, never at all silvery; specimens often fragmentary, but when intact the single stem can be seen to rise from the thick annual tap-root .....(17)

(17) Plants often as much as 60 cm. tall, mature capsules 5 to 8 mm. long. 10. *C. texensis* (Klotzsch) Muell. Arg.

(17) Plants more robust, often 100 cm. tall, mature capsules 8 to 9 mm. long
.....11. *C. Parksii* Croizat

KEY TO EXCLUSIVELY STAMINATE MATERIAL

(1) Petioles of lower leaves at least half as long as the blades they support ..... (2)
(2) Blades tapering from near the middle to the pointed acute apex, which forms a 40–70° angle ..... (3)
(3) Stipules and margins of leaves conspicuously glandular-ciliate ..... 13. *C. ciliatoglandulosus* Ort.
(3) Stipular and foliar glandular ciliation, when present, not noticeable without a lens ..... 14. *C. humilis* L.
(2) Blades more rotund, rounded at apex, or if pointed the angle greater than 100° ..... 8. *C. punctatus* Jacq.
(1) Petioles of lower leaves less than half as long as the blades they support ..... (4)
(4) Blades mostly shallowly cordate at base ..... 18. *C. fruticulosus* Engelm.
(4) Blades never, or very rarely, cordate at base ..... (5)
(5) Blades usually more than 3 times as long as broad, linear or oblong-lanceolate ..... (6)
(6) Leaves silvery scaly canescent beneath, dark grayish above; base of plant usually manifestly ligneous with several stems (perennial, but flowering first year) ..... 9. *C. dioicus* Cav.
(6) Leaves green, yellowish-green, or yellowish-gray, never at all silvery; specimens often fragmentary, but when intact the single stem can be seen to rise from the thick annual tap root ..... (7)
(7) Plants often 90 cm. tall, not coarsely tomentose 10. *C. texensis* (Klotzsch) Muell. Arg.
(7) Plants more robust, often 120 cm. tall, coarsely tomentose ..... 11. *C. Parksii* Croizat
(5) Blades, at most, 3 times as long as broad, usually less ..... (8)
(8) Leaves scaly silvery canescent beneath ..... 9. *C. dioicus* Cav.
(8) Leaves not scaly silvery canescent beneath ..... (9)
(9) Leaf-blades oblong (most of them well more than twice as long as broad, tomentose beneath, above short-pubescent and not tomentose) .... 15. *C. Torreyanus* Muell. Arg.
(9) Leaf-blades tapering from near the middle to the apex ..... (10)

(10) Leaf-blades widest near the middle, tapering to a pointed apex and to a pointed or shortly rounded base, rarely with cordate tendencies .....(11)

(11) Leaf-blades thick, rough tomentose on both sides; about twice as long as wide..... .....16. *C. suaveolens* Torr.

(11) Leaf blades not thick, with a smooth, short grayish tomentum beneath, but green and glabrous or with only a light, non-tomentose pubescence above, usually more than twice as long as broad.... ....17. *C. Cortesianus* H.B.K.

(10) Leaf-blades ovate, tapering from near the base to the apex (tomentose on both surfaces)..... .....18. *C. fruticulosus* Engelm.

The species can be put into four groups for the purposes of discussion. These groups are not intended to be considered taxa; a modern reorganization of the genus must await a comprehensive survey.

Maps are provided to show the distribution of the Crotons in Texas, as indicated by herbarium specimens. No map is provided for *C. punctatus Jacq.*, a secies of littoral plants; nor is one given for *C. ciliatoglandulosus* Ort., of which only one specimen has been collected in Texas.

GROUP I (SPECIES 1–5)

This group includes the monoecious herbs in which the pistillate calyxes are deeply 5-lobed, the staminate flowers are petaliferous, and the pistillate not (except for very minute petals in *C. glandulosus* L.), and each of the styles is only once bifurcate, giving 6 ultimate stigmatal ends (except in *C. monanthogynus*, in which only two styles develop, giving four ends). All are species of herbs, not very robust ones, with stellate pubescence. In all of them, the staminate calyxes, which are quite small, frequently have one lobe suppressed, giving a variable ratio of 4- and 5-lobed staminate calyxes on almost every plant. Of the five species, *C. glandulosus* stands by itself in having no

close relatives among the others, and in ranging far into tropical America. The other four species are fairly closely related, each at times assuming vegetative form strikingly similar to another, but always quite distinct in significant characters. All four are warm-temperate North American species. *C. corymbulosus* in some growth forms superficially resembles *C. dioicus* Cav. (No. 9) .

1. C. GLANDULOSUS L., Syst. ed. 10, p. 1275. 1759. The original material was collected by Patrick Browne in Jamaica, and the name may be typfied by *LINN 1140.1*, as listed by Savage (1945: 173).

This species of annual herbs has several varieties, and ranges as far south as Central America and Brazil. The var. *glandulosus* is West Indian. Without a thorough field review of the species in peninsular Florida, the number of varieties found in the United States remains uncertain. Outside of Florida, three varieties occur in the United States; all three are also found in Texas. Plants of all these varieties show a great preference for sandy loam, but are somewhat weedy and do invade and survive in fairly tight clay loam, becoming depauperate in the tighter soils.

KEY TO THE TEXAS VARIETIES OF CROTON GLANDULOSUS

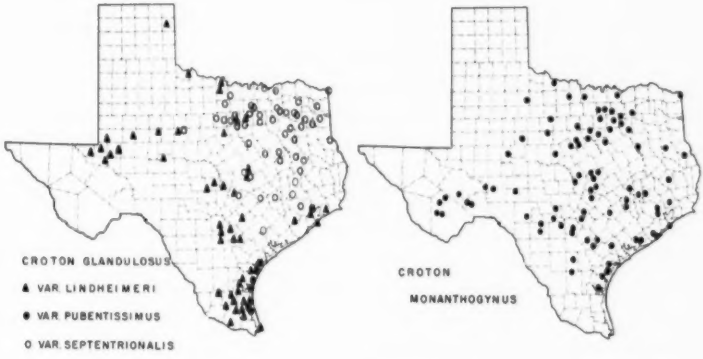
(1) Plants relatively robust, in Texas usually 2–3 dm. tall or taller (up to 6 dm. elsewhere, fide Fernald, 1950: 960); larger leaves at least 3 cm. long, usually 3–5 cm. .....(2)
(2) Stems variously pubescent but not coarsely hispid; seeds about 3.5 mm. long ....1a. var. *septentrionalis* Muell. Arg.
(2) Stems coarsely hispid; seeds about 4 mm. long .....
.....1c. var. *pubentissimus* Croizat
(1) Plants less robust, averaging 1–2 dm. tall; larger leaves about 2.5 cm. long .....1b. var. *Lindheimeri* Muell. Arg.

1a. C. GLANDULOSUS var. SEPTENTRIONALIS Muell. Arg. in DC., Prodr. 15(2): 686. 1866. Little Rock, Arkansas, *Engelmann 6* (MO; cf. the discussion by Croizat, 1945: 188).—*C. glandulosus* var. *angustifolius* Muell. Arg. l.c Dry woods, Houston, Harris County, Texas, June, 1843, *Lindheimer I 172* (Croizat, l.c., presumes that Ferguson, 1901: 53, bases the name on this specimen).

Plants of this variety occur throughout the southeastern United States, north to Maryland, Ohio, Indiana, Illinois, and Iowa, west to Kansas and Oklahoma and Texas. In Texas this variety intergrades on a broad scale with the var. *Lindheimeri* Muell. Arg.

1b. C. GLANDULOSUS var. LINDHEIMERI Muell. Arg. in DC., Prodr. 15(2): 685, 1866. On the Llano River, Texas, *Lindheimer 691*.

—*C. glandulosus* var. *Croftiae* Ferguson in Small, Fl. SE. U. S. p. 696, 1903, published as a new name for var. *Lindheimeri*, superfluous and hence illegitimate.—*C. glandulosus* var. *parviseminis* Croizat, Journ. Arn. Arb. 26: 188, 1945. Texas, *Lindheimer 691b* (GH-A).



Plants of this variety occur extensively in Texas, but in general occupy a more southern and western range than those of the var. *septentrionalis*; some individuals can be referred to one or the other of these varieties only arbitrarily. Plants of the var. *Lindheimeri* occur near the coast in Tamaulipas. In the southern part of that state this variety intergrades with another, perhaps the var. *intermedius* Muell. Arg.

1c. C. GLANDULOSUS var. PUBENTISSIMUS Croizat, Journ. Arn. Arb. 26: 188, 1945. Padre Island, Kleberg County, Texas, 1940, *Cory s.n.* (A-GH).—*C. glandulosus* var. *hirsutus* Shinners, Field & Lab. 19: 183, 1951. Frequent in sandy open woods 6.5 northeast of Rockport, Aransas County, Texas, *Cory 54597* (SMU).

The plants of this variety are confined to loose deep fine sand in the immediate vicinity of the Texas coast from extreme eastern Willacy County to Aransas County, with one record from near Channelview, Harris County.

2. C. MONANTHOGYNUS Michx., Fl. Bor.-Am. 2: 215, 1803. The original material was from "Tennassée, juxta Nashville" and is now presumably in the Richard herbarium (P).

Plants of this species occur in the Gulf coastal states (except Florida), north to southern Maryland, southern Ohio, Indiana, and Iowa, and west to eastern and west-central Kansas, west-central Oklahoma, and western Texas. They are weedy annual herbs occurring in soils of

all textures (except loose sand), but preferring fine calcareous loams, and are most abundant in overgrazed prairies and barrens, and along roads. The range is apparently more extensive today than it was 100 years ago. Deam (1940: 638) gives his opinion and evidence that the species is adventive in Indiana. Wheeler (in Kearney & Peebles, 1951: 504) records it from Arizona on the basis of *Mearns 1167* (US) from the Santa Cruz River at La Noria, Santa Cruz County, saying it is probably adventive from farther east. I have seen four collections from Mexico: Monterrey, Nuevo Leon, 1902 and 1911, *Pringle 1913 & 11164;* Sierra Guascama, Minas de San Rafael, San Luis Potosi, June 1911, *Purpus 5481;* and Cerro del Chino, near San Miguel, central Tamaulipas, July 1930, *Bartlett 10711.*

Croton monanthogynus is fairly uniform throughout its range, at times approaching the closely related *C. Lindheimerianus* var. *Lindheimerianus* in appearance, but always easily separable by the key characters. I have seen only one specimen which exhibited a mixture of flowers, some with 3-celled, 3-seeded ovaries and 6 stigmatal ends, and some with 2-celled, 1-seeded ovaries and 4 stigmatal ends: limestone slopes 7 miles west of San Marcos, Hays County, Texas, November 2, 1954. *Gould 6686* (TEX).

3. C. LEUCOPHYLLUS Muell. Arg., Linnaea 34: 139, 1865.

This species has two strong varieties, which do not occur together, and which perhaps should be treated as species. Without field study in Nuevo Leon and Tamaulipas I am reluctant to change the nomenclature. Only the nominate variety occurs in Texas, but I will also list the Mexican variety to call attention to the problem.

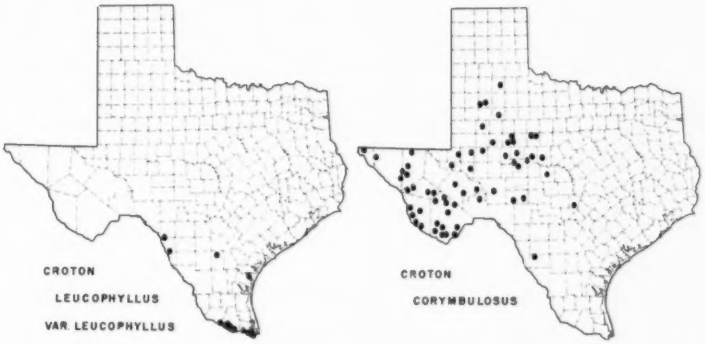
KEY TO THE VARIETIES OF CROTON LEUCOPHYLLUS

(1) Plants soft appressed pubescent; pistillate calyxes with 3 well-developed abaxial lobes and usually 2 weak adaxial ones.... .....3a. var. *leucophyllus*

(1) Plants coarsely raised pubescent; pistillate calyxes usually with only 3 well-developed lobes, the other two being vestigial or suppressed .....3b. var. *trisepalis* Ferguson

3a. C. LEUCOPHYLLUS var. LEUCOPHYLLUS. The label of an isotype reads: "Entre el Rio de Medina y el Rio de last Nueces. Julio 1829," which would be from Atascosa County or McMullen County, southern Texas, *Berlandier 2024=614* (GH). Ferguson (1901), curiously cited *Berlandier 614* "(ex. 2), July 1823," and "2424, July 1825," but of course Berlandier did not reach the New World until late in 1826 and did not enter Texas until early in 1828. Ferguson's "2424"

is aparently an error for *2024*.—*C. Palmeri* Wats., Proc. Amer. Acad. 18: 152, 1883. Soledad, a section of low mountains about 25 miles southwest from Monclova, Coahuila, Sept. 9–19, 1880, *E. Palmer 1239* (GH, US, PH). McVaugh (1956: 323) gives the coordinates of "Sole-



dad, Coahuila" to the nearest minute; the only Soledad I can find in the vicinity of Monclova is 38.5 miles southeast of Monclova at an elevation of about 2500 ft., just across the state line in Nuevo Leon.

These annual herbs are not weedy; they occur among open low woody vegetation. On the Recent delta and floodplain of Rio Grande the variety is frequent, being represented by 20 collections from Starr, Hidalgo and Cameron counties. Seven specimens from widely scattered localities are the only records of its occurrence elsewhere; these seem worthy of listing: (1) type of the nominate variety, from Atascosa or McMullen County; (2) type of *C. Palmeri*, this being the only Mexican record; Palmer must have found a colony, for he collected at least eight uniform entire plants; (3) Kinney County, 9 miles south of Spofford, October 6, 1935, *Cory 16773* (GH); (4) McMullen County, 1.7 miles north of Tilden, November 5, 1953, *Shinners 16962* (SMU); (5) Maverick County, low clay prairies, Eagle Pass, *V. Havard s.n.* (US); (6) Nueces County. Corpus Christi, September 21, 1936, *Cory 20653* (GH); (7) Nueces County, Corpus Christi, August 13, 1941, *Fisher 41092* (US). The paucity of collections from Mexico can be taken as an indication of scanty collecting, but the wide scattering of the Texas records indicates infrequence or rarity except on the delta of the Rio Grande.

3b. C. LEUCOPHYLLUS var. TRISEPALIS Ferguson, Ann. Rept. Mo. Bot. Gard. 12: 57, February 16, 1901. Monterrey, Nuevo Leon, July 11, 1888, *Pringle 2225* (GH).—*C. Palmeri* var. *ovalis* Fernald,

Proc. Amer. Acad. 36: 493, April 22, 1901. Monterrey, Nuevo Leon, October 11, 1895. *Seler & Seler 1047* (GH). Wheeler (1939: 36–37) first published this synonymy. Ferguson did not designate a type. If MO possesses a sheet of *Pringle 2225*, it should be taken as the holotype.

In addition to the four collections cited by Wheeler (l.c.), all from Monterrey, I have seen the following: (1) Monterrey, May 1891, *Dodge 133* (US); (2) shale plain east of Linares, Nuevo Leon, *Bartlett 10836* (US). The label of *Pringle 11163* says "Fields, Monterrey," this being the only indication of possible weediness in this variety. The variety seems to be endemic to central Nuevo Leon.

4. *C. corymbulosus* Engelm. in Rothrock, Rept. Wheeler's Exped. VI, Bot. p. 242, 1878.

KEY TO THE VARIETIES OF CROTON CORYMBULOSUS

(1) Leaf-blades more than 1.5 cm. long, most longer than 2 cm.; stems branched but the branches not greatly divergent, and not zig-zag; inflorescences mostly more than 1 cm. long; styles usually more than 1 mm. long .....4a. var. *corymbulosus*

(1) Leaf-blades 1.5 cm. long or shorter; stems divaricately branched, tending to zig-zag; inflorescences short, about 1 cm. long; styles about 1 mm. long .....4b. var. *thermophilus*

4a. C. CORYMBULOSUS var. CORYMBULOSUS. Camp Bowie in Apache Pass, Chiricahua Mountains, elev. 5000 ft., Cochise County Arizona, July 1874, *Rothrock 506* (MO, US).—*C. eremophilus* Wooton & Standley, Contr. U. S. Natl. Herb. 16: 144, 1913, Dog Spring, Dog Mountains, southeastern Hidalgo County, New Mexico, September 16, 1893, *E. A. Mearns 2336* (US). I agree with Wheeler (in Kearney & Peebles, 1951) in this synonymy.—? *Lasiogyne Pottsii* Klotzsch in Seemann, Bot. Voy. Herald, p. 278, 1855. Chihuahua, *Potts* (K?).—*Croton Pottsii* (Klotzsch) Muell. Arg. in DC., Prodr. 15(2): 561, 1866. Mueller, not having seen Potts' collection, was uncertain of the disposition of the name, and merely echoed Klotzsch's description. Standley (1923) did not take the name into account at all. Judging from the description and the locality, this is an earlier name for *C. corymbulosus* or for *C. suaveolens* Torr., probably the former.

These are perennial herbs or subshrubs, in Texas as much as 7 dm. tall, but usually much shorter. They occur in arid, mostly calcareous, uplands, from Querétaro northwest to northeastern Sonora, southeastern Arizona, southern and central New Mexico, and western Texas.

The plants from the extreme southern part of the range and from parts of Chihuahua are depauperate, but all appear to be of this species.

4b. C. CORYMBULOSUS var. THERMOPHILUS M. C. Johnston, new variety. Foliorum laminae 1.5 cm. longae vel minores; caules divaricato ramosi, subflexuosi; inflorescentia brevis ca. 1 cm. longa; styli ca. 1 mm. longi.

Perennial herbs from tap roots about 5 mm. thick, suffrutescent, 2.5–5.5 dm. tall, much-branched from the base and above, the branches above diverging at the bases of the old determinate inflorescence axes, usually forming angles of greater than 50°, often as much as 75°; entire plant rather shaggily canescent stellate-tomentose (the older stems glabrescent, brownish); leaves alternate, stipules minute and falling early, petioles more than half as long as the blades they support, blades about 1–1.5 cm. long, ovate, entire, acute, rounded or very obscurely cordate at base, pinnate-nerved, the midvein and the 3–5 pairs of laterals prominent beneath, the laterals curving to the margin; racemes terminal, 10–25–flowered, the axes eventually about 1 cm. long, the lower moiety of flowers pistillate and short-pedicellate, the upper staminate and almost sessile, each pedicel subtended by a minute caducous subulate bract; the fruiting pedicels elongating, the fruit becoming pendulous; pistillate calyxes equally deeply 5-lobed, the lobes oblong, about as long as the ovary but only half as long as the fruit at maturity; pistillate flowers devoid of petals; ovary 3-celled; styles 3, each bifurcate at the base, giving six stigmatal ends, about 1 mm. long; staminate calyxes small, mostly 5- (a few 4-) lobed; petals oblong, as many as, as long as, and alternate withe calyx lobes, brownish and thick when dry; stamens 11; fruit 3-seeded, about 4 mm. long, a little less in diameter; seeds about 3.25 mm. long, oblong or slightly enlarged chalazally, minutely rugose, shiny, pale brownish with fuscous mottling. TYPE: Brewster County, Texas, locally abundant in desert on low basalt hills in Big Bend National Park about midway between the main road and Dagger Flat (altitude about 2550 ft.), July 21, 1952, *G. L. Webster 4439* (holotype, SMU; isotype SRSC).

Plants of this variety are known from a fairly small area in southern Brewster County. I was long uncertain whether to dub these plants with a Latin name. Dr. Barton H. Warnock of Sul Ross State College assures me that the plants have an appearance quite different from the typical *C. corymbulosus*, and occupy a different habitat. The typical variety is most abundant in overgrazed grama grasslands on slopes at moderate elevations, whereas the var. *thermophilus* stays to the hot, rocky desert lowlands. Other collections seen, all from Brewster County, are:

(1) infrequent in sandy soil at head of Boquillas Canyon, Big Bend National Park, alt. 2100 ft., October 31, 1948, *Turner & Warnock* 8321 (SRSC); (2) frequent in limestone soil at head of Heath Canyon, Black Gap Refuge, alt. 2250 ft., August 25, 1950, *Warnock & Hinckley BG–212* (SRSC); (3) infrequent in canyon on north side of Talley Mountain, Big Bend National Park, alt. 2500 ft., May 11, 1955, *O. C. Wallmo 18* (SRSC).

5. C. LINDHEIMERIANUS Scheele, Linnaea 25: 580, 1852.

KEY TO THE VARIETIES OF CROTON LINDHEIMERIANUS

(1) Leaf-blades suborbicular, rhombic-ovate, or oblong, many of them less than twice as long as wide, the apexes rounded to broadly acute; most with apical angles greater than 85°; plants densely velvety appressed tomentose; at least some of the fruiting pedicels curved, the fruit drooping at maturity. 5a. var. *Lindheimerianus*

(1) Leaf-blades lance-ovate, many of them more than twice as long as broad, acute, most with apical angles of less than 90°; plants relatively rough tomentose; fruiting pedicels erect .....
.....5b. var. *Tharpii* M. C. Johnston

5a. C. LINDHEIMERIANUS var. LINDHEIMERIANUS. The original material was collected "auf sterilen Boden umweit Neubraunfels," Comal County, by Lindheimer, but was probably destroyed at Berlin.

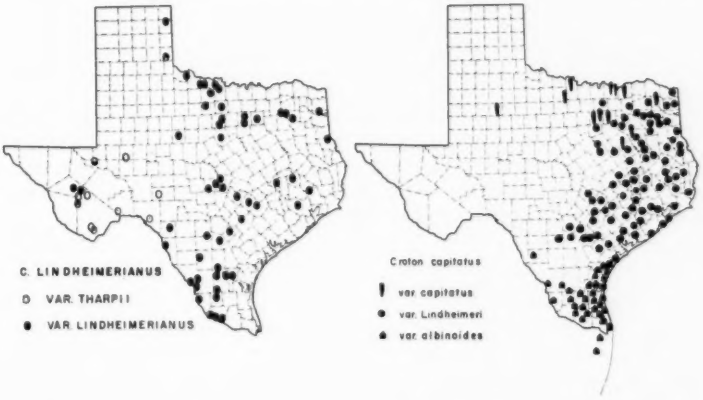
Plants of the nominate variety occur in Texas and much of Oklahoma, north to Harper County, Kansas, east to Logan County, Arkansas, and south to northeastern Coahuila (and probably extreme northern Tamaulipas). They are annual herbs, with slight weedy tendencies, preferring sandy loam, but occurring also on gravel and clay loam, never on loose dune sand.

5b. C. LINDHEIMERIANUS var. THARPII M. C. Johnston, new variety. Foliorum laminae lanceolato-ovatae, saepe longitudine latitudienem plus quam duplo excedente, acutae; planta sat scabridotomentosa; pedicelli fructigeri erecti.

Annual herbs from tap roots 2–8 mm. thick, erect, repeatedly branched at the bases of the inflorescence axes, 0.2–4 dm. tall, entire plant stellate tomentose, the stems and upper surfaces of the leaves yellowish-green, and the lower surfaces of the leaves grayish-green; petioles long, the lower ones about as long as or longer than the blades which they support; blades lance-ovate, entire, acute, rounded at the base, the largest 8 x 3.5 cm., the average 3 x 1.2 to 5 x 2 cm.,

the blades pinnate-veined, the midveins prominent beneath, the laterals less so; raceme as in the typical variety, few-flowered, terminal, and determinate, branches from the base also bearing racemes, several racemes of various ages being visible at once, so the lower maturing fruit sometimes appearing axillary or nodal; fruiting pedicels about 5 mm. long and erect; pistillate calyxes equally deeply 5-lobed, the lobes oblong about as long as the ovary in flower and accrescent, about equalling the fruit at maturity; pistillate flowers devoid of petals; ovary 3-celled; styles 3, each bifurcate at the base, giving 6 stigmatal ends, about 1.5 mm. long; staminate calyxes small, 5-(some 4-) lobed; petals linear-lanceolate, as many as, as long as, and alternate with, the calyx-lobes, pale brownish and papery when dry; stamens several; fruit 3-seeded, about 4–4.5 mm. long, about the same in diameter; seeds about 3.25 mm. long, oblong, minutely rugose, shiny, mottled brown and fuscous. TYPE: Brewster County, Texas, infrequent in limestone washes at Dog Flat, Big Bend National Park, alt. 3500 ft., August 26, 1951, *Warnock 9977* (holotype, SMU; isotype, SRSC).

The var. *Tharpii* occurs in near-desert loamy or rocky flats in west-



ern Texas and northern and western Coahuila. Some specimens look much like *C. leucophyllus* (several were determined as *C. Palmeri*) but there seems to be no gradation to that species. On the other hand, there is very close affinity to and intergradation with the nominate variety of *C. Lindheimerianus*. Intermediate specimens have been seen from Comanche County, Oklahoma, and from Collingsworth, Ward, and Brewster counties, Texas. A single specimen of the var.

Tharpii from gravelly soil at Beaver Creek, Yavapai County Arizona, September 1903, *Purpus 8258* (US) is the basis of the inclusion of the species by Wheeler among the Arizona Crotons (in Kearney & Peebles, 1951: 504); Wheeler says it is perhaps introduced in Arizona. I have seen no evidence of its occurrence in New Mexico. Interestingly enough, the draws and washes of the old volcanic mountains of eastern Jeff Davis County and northern Brewster County, Texas, harbor both varieties and intermediates. Other specimens seen are cited below.

TEXAS. Brewster County: frequent, floodplain out of Sunny Glenn about 5 miles northwest of Alpine, October 25, 1940, *O. E. Sperry T889* (US); 26 miles northeast of Alpine, September 19, 1940, *Cory 3557* (A-GH); Glass Mountains near Old Blue Flat, August 25, 1941, *Warnock 20015* (TEX); infrequent in limestone area between Dog Flat and Persimmon Gap, Big Bend National Park, alt. 3400 ft., September 6, 1950, *Warnock 9642* (SRSC). Jeff Davis County: rare in soil from igneous rocks in Limpia Canyon, Wild Rose Pass, Davis Mountains, alt. 4700 ft., May 24, 1949, *Warnock & McVaugh 8655* (SRSC). Midland County: lake bed 29 miles southeast of Midland, October 8, 1942, *Cory 40607* (TEX) & *40609a* & *40609b* (A-GH). Sutton County: Substation No. 14, Pasture L., July 12, 1940, *Cory 35076* (A-GH). Terrell County: very frequent even with concrete slab at Camp Ground, 10 ft. above water, edge of Independence Creek a half-mile above its mouth, July 8, 1950, *Surratt 15* (SRSC). Val Verde County: frequent in calcareous soil along highway north of Comstock, alt. 1100 ft., August 31, 1955, *Warnock 13160* (SRSC).

COAHUILA: fairly common on flat in valley northeast of Sierra del Pino 20 kilometers west of San Guillermo, Sept. 20, 1941, *Stewart 1769* (A-GH); scattered on rocky floor of arroyo, Canon Bocatoche, Municipio de Castaños, Sept. 2, 1939, *C. H. Mueller 3131* (GH-A); erect in bed of ephemeral charco in barreal on the broad valley floor less than 16 kilometers east of Puerto del Caballo on the road to Tanque Jerico, circa lat. 27°27′ North, Aug. 22–23, 1941, *I. M. Johnston 8331* (A-GH); erect in tobossa-flat at edge of mogote 7 miles south of Jaco on the road to El Almagre, Sept. 10, 1940, *Johnston & Mueller 1120* (A-GH); common, ascending, on llano 12 kilometers east of Tanque Toribio, south of Las Delicias on the road to Puerto del Ventanillas, Oct. 11, 1942, *R. Santos sub Stewart 2978* (A-GH).

GROUP II (SPECIES 6 AND 7)

This group includes two species of monoecious annual herbs in which the calyxes are deeply lobed, the staminate flowers have 5-lobed calyxes and well-developed petals alternating with glands, the pistillate flowers 6–10-lobed calyxes, and each style is at least twice bifurcate.

6. C. CAPITATUS Michx., Fl. Bor.-Am. 2: 214, 1803.

KEY TO THE VARIETIES OF CROTON CAPITATUS

(1) Leaf-blades blunt, not tapered strongly from the base, the petioles long, as long at the top of the plant as at the middle; seed smooth

and even-colored, nearly circular, lenticular (ventrally compressed), large (5 mm. in diameter).....6a. var. *capitatus*.

(1) Leaf-blades tapering from near base to apex, the petioles long at the middle of the plant becoming progressively shorter toward the top (blades sometimes obscurely serrate); seeds longer than broad, the degree of ventral compression variable; usually mottled slightly, and the slight testal roughening often evident through the aril .....(2)

(2) Seeds fairly large, but mostly less than 5 mm. long, and usually oblong as seen from the back.....
.....6b. var. *Lindheimeri* (Engelm. & Gray) Muell. Arg.

(2) Seeds smaller, usually less than 4 mm. long, and oblong or obovate, being broadest toward the chalaza.....
.....6c. var. *albinoides* (Ferguson) Shinners.

6a. C. CAPITATUS var. CAPITATUS. Illinois, *Michaux* (Type, P, not seen; photo of type seen, GH).

From northern Texas, the plants of this variety range through central and eastern Oklahoma to eastern Kansas, and east through scattered parts of Arkansas and most of Missouri to scattered parts of southern Illinois, southern Indiana, southwestern Kentucky, and central Tennessee, and to extreme northwestern Georgia. The scattering in the eastern portion of the range seems to be attributable partly to the preference for isolated barrens and glades in otherwise densely forested country, and partly to erratic dispersal of the seeds of this weed. As an adventive weed the typical variety has been found as far as the Great Lakes; Adams Co., Ohio; Lancaster County, Pennsylvania; Talbot County, Maryland; Mobile County, Alabama, eastern Virginia, and southern New York (cf. Fernald, 1950: 960). Deam (1940: 637) says this species seems to be adventive in Indiana from farther south.

6b. C. CAPITATUS var. LINDHEIMERI (Engelm. & Gray) Muell. Arg. in DC., Prodr. 15(2): 687, 1866, based on *Pilinophytum Lindheimeri* Engelm. & Gray, Pl. Lindh. 1: 232, 1845. Dry prairies, Houston to the Brazos, in 1843, *Lindheimer I 171* (holotype, GH; isotypes, SMU, PH).—*C. Engelmannii* Ferguson, Ann. Rept. Mo. Bot. Gard. 12: 54, 1901, as a new name for the last, superfluous and illegitimate.—*C. Lindheimeri* (Engelm. & Gray) Wood, Class Book Bot. p. 631, 1861, based on *P. Lindheimeri*.—Perhaps this entity finds an earlier name in *Heptallon simplex* Raf. Aut. Bot. p. 47, 1840, or in *H. lanceolatum* Raf., l.c., p. 48, but the descriptions do not suffice for the determination of those names.

Plants of var. *Lindheimeri* occur from eastern Texas, extreme east-

ern Oklahoma (LeFlore County), extreme southeastern Missouri, and extreme southwestern Tennessee, through most of Arkansas, Louisiana, Mississippi, and Alabama, to central and southern Georgia, and northern Florida, thus occupying, on the coastal plain, a more southerly range than the nominate variety. As an adventive weed the var. *Lindheimeri* has been collected in eastern Kansas (Miami County), southwestern Kentucky (Christian County), and Indiana (Lake County). The ranges of the var. *capitatus* and the var. *Lindheimeri* do not overlap extensively; only a handful of the several hundred specimens examined could be considered intermediate, and these were from the area of overlap of range, in northeastern Texas and parts of Arkansas. Engelmann & Gray (1845: 232–233) note that "something like intermediate specimens between [*Pilinophytum Lindheimeri*] and *P. capitatum*, which also grows in Texas, render it doubtful . . . whether *[P. Lindheimeri]* is specifically distinct." Actually certain of Lindheimer's specimens which Gray ticketed as *P. capitatus* I would place in *Lindheimeri*. The entity *Lindheimeri* has been treated as a species distinct from *C. capitatus* by almost all workers except Mueller Argoviensis (1866: 687), who had fewer specimens to work with than any of the Americans who treated the species; and Coulter (1894: 399) who thoroughly misunderstood the species; and Gleason (1952: 475). Croizat (1942: 448) says that the "two entities differ both in intangibles and in characters and can be recognized without much difficulty by anyone who has learned how to identify them," which I think no one would trouble to contest. Judging from his annotations, L. C. Wheeler, a very acute student of Euphorbiaceae, would consider *Lindheimeri* a distinct species, and so did Fernald (1950: 960). My reasons for using Mueller's combination will, I hope, be made clear below.

6c. C. CAPITATUS var. ALBINOIDES (Ferguson) Shinners, Field & Lab. 19: 183, 1951, based on *Croton Engelmanni* [var.] *albinoides* Ferguson, Ann. Rept. Mo. Bot. Gard. 12: 55, 1901. Very abundant in dry ground near the Arroyo at Corpus Christi, Nueces County, Texas. May 30, 1894, *Heller 1800* (MO, isotypes seen, US, UC, GH), locality data taken from Heller (1895: 58).—*C. albinoides* (Ferguson) Croizat, Bull. Torr. Bot. Club 69: 447, 1942, based on the last.—*Croton Berlandieri* Muell. Arg., Linnaea 34: 141, 1865 [non Torrey, 1859]. Llano de Santa Teresa [on the Rio Grande delta out of Matamoros on the road to San Fernando, northeastern Tamaulipas,] *Berlandier 2281=861* (holotype, Berlin, still extant?; isotype seen, GH).—*Croton Muelleri* Coulter, Contr. U. S. Nat. Herb. 2: 399, 1894, as a new name of the last.

In a long discussion, Croizat (1942: 448–450) seems to maintain that *albinoides* differs as much from typical *capitatus* as it does from *Lindheimeri*, and constitutes a "connecting link" between them. Some of his discussion evinces that certain unfamiliarity with American geology and geography which is remarkable also in another more ambitious opus. He recognizes four species, *capitatus*, *Lindheimeri*, *albinoides*, and *Muelleri*. The seeds of each of these, he says, differ from those of every other "in about the same degree, and taken together they bespeak uniform speciation within a fundamental consanguinity." He maintains that the ripe capsule of *Lindheimeri* is significantly longer, the calyx lobes more regular, the floral indumentum of different color, and the tomentum fluffier than in *albinoides*.

In spite of Croizat's full discussion, the facts remain that on a broad scale *albinoides* intergrades with *Lindheimeri* in southern Texas; the characters that he evokes for their separation are not at all constant; and the color of the trichomes of the inflorescence has very little significance (as revealed in the field and in the herbarium) except as a vague coastward trend in southern Texas. Characters of seed form and size are not nearly so constant and valuable as Croizat would have them. The seeds tend to be significantly smaller southward in the coastal plain, being smallest in northeastern Tamaulipas. *C. Muelleri* is a depauperate clay-land ecotype (as contrasted to the more abundant robust sandy-land forms) with shorter petioles and smaller blades, in fact with essentially all the parts, including the seeds, diminutive as compared with sandy-land plants of adjacent areas. The *Muelleri*-ecotype is found within the ranges of both *Lindheimeri* and *albinoides* as here taken, and intermediate specimens from situations of intermediate soil texture are numerous. The type of *C. Muelleri* is an extreme example of depauperate *albinoides* at the southern extreme of range. All these plants are strict annuals, though *C. Muelleri* was described as a perennial.

As may be inferred from the key, var. *albinoides* and var. *Lindheimeri* are much closer to each other than either is to typical *C. capitatus*. It would be quite acceptable to me to treat *Lindheimeri* as a species with *albinoides* as its second variety (just as Ferguson did). Yet, all these plants are close enough that, in the absence of data revealing the actual biological relationships between *capitatus* and *Lindheimeri*, I am reluctant to add one more combination to the cluttered nomenclature. So I use Mueller Argoviensis' and Shinners' combinations. The latter prevails by Article 60 of the 1956 Code of Nomenclature.

7. C. CORYI Croizat, Bull. Torr. Bot. Club 69: 446, 1942. Kleberg County, Texas, on Padre Island 26 miles south of Port Aransas, No-

vember 1940, *Cory s.n.* (holotype, which must be considered a unicate, seen, A-GH).

C. Coryi is one of the handful of species endemic to the eolian plain of southern coastal Texas. It is a species of robust annual herbs (but described as "a shrubby perennial") from stout tap roots often ligneous at the base of the stem and often as much as 75 cm. tall. The entire aerial portion of the plants, except stamens, petals, and seeds, is densely whitish stellate tomentose. In the field the plants are distinctive by virtue of the very white foliage and the beautiful petals of the staminate flowers, five to each flower, each about 3 mm. long, ovate, and covered with bright silvery round scales. Another distinctive feature is the great sap pressure; the removal of a leaf releases several milliliters of clear or slightly milky sap (turning brownish-red on exposure) within a few minutes from the fresh leaf-scar.

C. Coryi always keeps to prairies on deep, loose, fine, eolian sand. Though like other Crotons it is apparently shunned by livestock, it is nowhere so abundant in grazed range as are *C. capitatus* var. *albinoides* and *C. Parksii*, with which it occurs.

GROUP III (SPECIES 8–12)

Group III includes the herbs (some suffrutescent) in which the calyxes are all shallowly lobed (nearly star-shaped) and the columellas winged. In most of the five species included, the flowers are all devoid of petals (exception: staminate flowers of *C. argyranthemus*), most are dioecious (exceptions: *C. argyranthemus* and *C. punctatus*), most have the styles at least twice bifurcate (in *C. argyranthemus* they appear trifid or quadrifid), most have uniformly 5-lobed pistillate calyxes (those of *C. argyranthemus* are usually 5-lobed but vary to 6- or 7-lobed), and most are perennial (exceptions: *C. texensis* and *C. Parksii*).

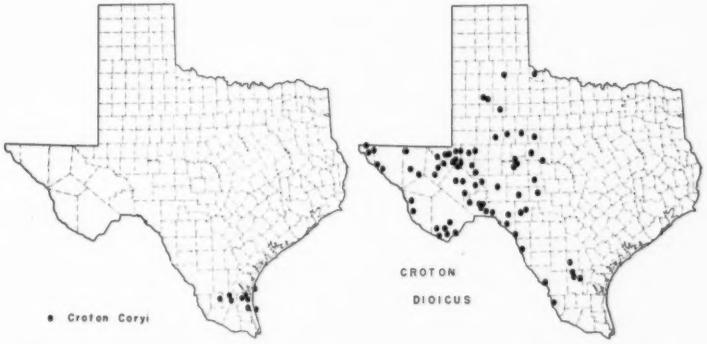
The species, excluding *C. argyranthemus* and adding the *C. californicus* Muell. Arg., seem to be a natural group, or part of one, and may be considered to constitute Mueller Argoviensis' section *Drepadinium* (1866). Bentham (1878: 223) issued a blanket condemnation of Mueller's ten sections of *Croton*, calling them "exceedingly unequal and very artificial, and yet not always easy to distinguish, each one, even those of only two species, comprising the most dissimilar forms." I am inclined to agree with Croizat (1942: 446) that *Drepadinium* "is one of the few natural groups" of Mueller's treatment.

C. argyranthemus is not closely related to the other species included here, nor is it a *Drepadinium*, but is closer to species of *Drepadinium*

than it is to any of the other Texas species. Croizat (1945: 187) suggests the possibility of its being a depauperate member of Section *Eleuteria* Grisebach, differing from that group in, among other characters, the humble stature, and the absence of petals in the pistillate flowers. It is conveniently included in this group for my purposes, since it is more likely to be confused with the species of *Drepadinium* than with other Texas species.

8. C. PUNCTATUS Jacq., Coll. ad Bot. Chem. et Hist. Nat. 1: 166, 1787. I am not sure that this name properly covers Texas plants. Ferguson (1901: 61) expressed no uncertainty as to the identity, and his usage has not been questioned, as far as I know.

These are plants of sandy coasts, pioneering on dunes near beaches, from North Carolina south on the Atlantic shores to Cuba and Ber-



muda, and on the Gulf and Caribbean shores to northern Venezuela and Colombia.

The temperate Pacific *Croton californicus* Muell. Arg. is extremely closely related to *C. punctatus*, the affinity being apparent in plants from the peninsular and mainland shores of the Gulf of California, especially in those from Sinaloa, and obscure in those polymorphic varieties which have invaded the Sonoran desert inland (see Wheeler in Kearney & Peebles, 1951).

C. punctatus has been collected in most of the coastal counties of Texas and probably occurs in them all.

9. C. DIOICUS Cav., Icon. 1: 4, tab. 6, 1791. The name may rest on the original illustration, prepared from a cultivated plant from Mexican seed.—*C. gracilis* H.B.K. Nov. Gen. & Sp. 2: 69 (quarto), 1817. Near Actopan, Hidalgo, *Humboldt* (type at Berlin?; photo of type at US, showing staminate plant only).—*C. neomexicanus* Muell. Arg.

Linnaea 34: 141, 1865. West Texas, *Wright 642* (Mueller also cited *Wright exs. 1800*).

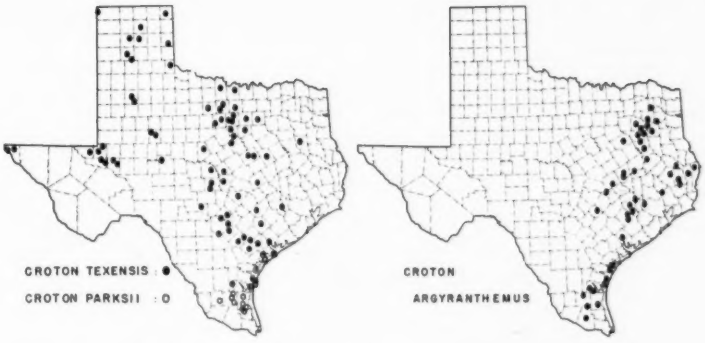
I am at a loss to know why this name has not been taken up before for what has usually been called *C. neomexicanus;* compare the synonymies of Ferguson (1901: 66) and Standley (1923: 614).

The species occurs in Oaxaca, Hidalgo, Puebla, San Luis Potosi, Durango, Zacatecas, eastern Chihuahua, Coahuila, Nuevo Leon, New Mexico, and Texas. Within this range it occurs on dry uplands, and is somewhat weedy in disturbed ground along roads and railroads. The plants of Oaxaca and Puebla are slightly more robust, with slightly larger and more numerous leaves, but the distinctions are weak, and probably not even of varietal importance.

10. C. TEXENSIS (Klotzsch) Muell, Arg. in DC., Prodr. 15(2): 692, 1866, based on *Hendecandra texensis* Klotzsch, Wiegmann Archiv. für Naturgeschichte 7: 252, 1841. Texas, *Drummond. C. muricatum* Nutt. Trans. Amer. Phil. Soc. n.s. 5: 173, 1835 [non Vahl ex Geiseler, 1807]. "On the sand beaches of the Great Salt river, Arkansas," *Nuttall* (BM?; type or isotype seen, PH, the locality given merely as "Arkansa").—*Croton virens* Muell. Arg. Linnaea 34: 142, 1865. Probably from near El Paso, El Paso County, *Wright exs. 1799* in 1951–1852 (B?).—*C. luteovirens* Wootn & Standley, Contr. U. S. Nat. Herb. 16: 145, 1913. Rio Gila, Grant County, New Mexico, August 15, 1902, *Wooton s.n.* (US).

These are essentially plants of sandy soil on the Great Plains, ranging north to southwestern South Dakota and eastern Wyoming, south through eastern Colorado, western Nebraska, western Kansas and western Oklahoma to western and south-central Texas. West of the Rocky Mountain system front range, they occur from north-central and northeastern Sonora and extreme northern Chihuahua north through Arizona and New Mexico to Juab County, Utah, and to southern Colorado. Many of the plants of the western portion of the range are of the form which has been called *C. virens* and *C. luteovirens*, but I must agree with Engelmann (in Rothrock, 1878: 243) and with Wheeler (in Kearney & Peebles, 1951: 504) that these do not merit recognition, though they are discrete geographically. They are most abundant in the Rio Grande valley near El Paso, and the valley of the Gila River.

C. texensis is something of a weed, occupying disturbed and shifting sand along rivers and in dunes, and on sandy roadsides and edges of fields. It has been found adventive in Cherokee County, Texas, Jackson County, Missouri, and Tallapoosa County, Alabama, and was collected once at Seaford, Delaware (September 10, 1896).



11. C. PARKSII Croizat, Bull. Torr. Bot. Club 69: 445, 1942. Sutherland Springs, Wilson County, Texas, October 1936, *H. B. Parks s.n.* (A-GH, pistillate and staminate plants on different sheets).

Croton texensis ranges south to south-central Texas, in Victoria, Goliad, and Karnes counties. In Wilson and Atascosa counties and in Aransas and eastern Refugio counties, in areas of deep sand, *C. texensis* intergrades with *C. Parksii*, whose center of distribution is in the deep sand eolian plain of Kenedy and Brooks counties. For the sake of consistency, *C. Parksii* might be reduced to synonymy under *C. texensis*, as has *C. virens*, or to varietal status. It is unfortunate that the type collection of *C. Parksii* is of intermediate individuals, from north of the main part of the range.

In its best development, in loose deep fine sand in northeastern Willacy County, Kenedy County, Brooks County, southeastern Jim Hogg County, and extreme eastern Kleberg, Nueces, and San Patricio counties, *C. Parksii* is a very robust annual herb (it was described as a shrub). The staminate plants attain heights of 160 cm., but probably average about 100 cm., and the pistillate plants are somewhat shorter. Flowering begins in June, and fruiting continues until late October, November, or December.

12. C. ARGYRANTHEMUS Michx., Fl. Bor.-Am. 2: 215, 1803. The original material was collected "in sylvis aridis Georgiae et Floridae," and is probably to be found in the Richard herbarium (P).

These are plants of the coastal plain, occurring from Tatnall and Emanuel counties, eastern Georgia south to central Florida, and west to Texas. The species has been collected within 25 miles of the Rio Grande in Hidalgo County, but I have not seen any Mexican collections. Well-drained, deep sandy soil is apparently a requirement for these plants. As is true for a number of sandy-land plants, they are

absent in the delta and floodplain of the Mississippi, and in those of the Rio Grande.

GROUP IV (SPECIES 13–18)

This last group receives the definitely shrubby Crotons. Their inclusion together here on the basis of habit is "natural" only in the sense that several of them are fairly closely related and all are only remotely related to other Texas Crotons. Their closest affinities may lie to the south with other woody species which do not reach Texas. In these six species the petals are developed in the staminate flowers, and not in the pistillate, the calyxes are all five-lobed, and all the vestiture is of stellate hairs, not of scales.

Croton Cortesianus is dioecious (in several dozen exsiccatae I find no examples in which staminate racemes and pistillate racemes occur on the same branch). This might be considered a good key character, except that in *C. humilis* and *C. ciliatoglandulosus*, which are often definitely monoecious, a pretty high proportion of the individuals are unisexual. And in the other three species, *C. suaveolens*, *C. Torreyanus*, and *C. fruticulosus*, the specimens are often so unsatisfactory that the monoecious condition is not readily apparent (Torrey described *C. fruticulosus* as being sometimes dioecious).

13. C. CILIATOGLANDULOSUS Ort., Hort. Matr. Dec. p. 51, 1797. Described from plants grown at Madrid from seed obtained by Sessé, purportedly from Cuba. Wheeler (in Benson & Darrow, 1954: 403) indicates that the seeds were probably actually of Mexican origin.

C. ciliatoglandulosus ranges in semiarid areas from Guatemala and Honduras north on the Pacific slope of Mexico to southern Arizona, and on the Gulf slope to southern Texas. The only two United States collections I have seen are: (1) mouth of Sycamore Canyon near Ruby, 3600 ft., Santa Cruz County, Arizona, October 13, 1944, *Darrow & Haskell 2215* (US); and (2) sandy soil 3.5 miles southwest of Roma, Starr County, Texas, December 1, 1933, *Clover 1392* (MICH, TEX). The first of those was cited by Wheeler (in Benson & Darrow, 1954: 233); the second was determined by Alexander in 1935, cited by Clover (1937: 93), and "verified" by Croizat in 1943.

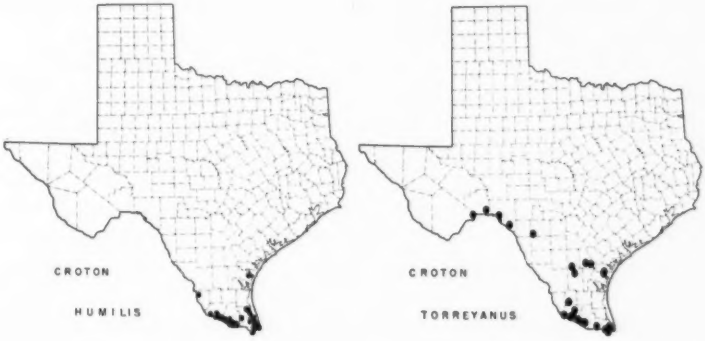
The weak dichotomy of the key points up the extremely close affinity of this species and *C. humilis*. This is evident also in Standley's key (1923: 612). The descriptions of Standley (l.c., pp. 616–617) indicate *C. ciliatoglandulosus* to be more robust and to have denser tomentum; while these differences seem to be borne out by herbarium studies, they seem scarcely of value as key characters, especially in the

extreme northern edge of range in southern Texas, where the one individual collected of *C. ciliatoglandulosus* was rather depauperate.

Field trips in the vicinity of the locality of Clover's collections failed to turn up any new records of the species in Texas in 1951 and 1954.

14. C. HUMILIS L., Syst. ed. 10, p. 1276, 1759. The original material may be taken as that which Browne obtained in Jamaica (*LINN 1140.19*, as listed by Savage, 1945: 173). *Croton Berlandieri* Torr., Bot. Mex. Bound. p. 193, 1859. Nuevo Leon, Thurber 869 (NY?, GH). Torrey also lists *Berlandier 708 = 2125* (NY?, GH, PH, K), which was collected in May, 1830, near Matamoros, Tamaulipas. Ferguson (1901: 40ff.) does not concur in the synonymy, saying that "all our forms are less glandular and more pubescent and have shorter-pedicelled flowers than the Jamaican forms of C. humilis."

Plants of this species range in the semiarid and subhumid lowlands of southeastern San Luis Potosí, Nuevo Leon, Tamaulipas, and south-



ern Texas; and in Yucatán, Puerto Rico, Jamaica, and southern Florida. Closely related forms occur on some of the other islands, but are sufficiently distinct to be excluded from the species. In the Yucatan peninsula occur plants of closely related species.

In the larger part of the range, in the brush country of northeastern Mexico and southern Texas, these shrubs are frequent in brush on clay loam and silty clay loam. They are rarely more than a meter tall. I have seen about four dozen collections from southern Texas and a great many more individuals in the field. Many of the plants have both pistillate and staminate flowers in the same raceme or in different racemes on the same plant, but apparently almost as often the shrubs are either all staminate or all pistillate, and in effect dioecious. No

other characters are correlated with these differences, so far as I can determine. Otherwise variability is not great.

Reports of *C. balsamiferus* Willd. from our area are based on specimens of *C. humilis* (Coulter, 1890: 49 and 1894: 399; Heller, 1895: 58).

15. C. TORREYANUS Muell. Arg. in DC., Prodr. 15(2): 579, 1866, based on Croton suaveolens var. β oblongifolius Torr. Bot. Mex. Bound. p. 194, 1859. Rocky ravines near Rio San Pedro (Devil's River, Val Verde County, Texas), October 1852, *Schott* Boundary Survey *No. 1295* (NY?, MO?).

Plants of this species occur in semiarid calcareous uplands from northern San Luis Potosí north through eastern Coahuila to Terrell County and southeastern Brewster County, Texas, and eastward, in central and northern Tamaulipas, Nuevo Leon, and in several counties in extreme southern Texas. In Cameron and Hidalgo counties, and Nueces and San Patricio counties, these shrubs forsake their customary limestone and take to somewhat calcareous well-drained clay loam near the Rio Grande and near Nueces bay.

16. C. SUAVEOLENS Torr., Bot. Mex. Bound. p. 194, 1859. "On the Rio Grande," presumably in trans-Pecos Texas, *Wright exs. 1804* (NY?).

These are low shrubs or actually more nearly perennial herbs, apparently restricted to the Limpia Canyon and Fort Davis vicinities of Jeff Davis County; I have seen about eight collections from that area.

Other specimens referred here by Standley (1923: 616) from Chihuahua, Coahuila, and San Luis Potosi may not be referable to this species.

Standley, following Mueller Argoviensis (1866: 659), keys this species as having "stipules palmately lobate." This would be misleading as far as the Jeff Davis County plants are concerned. Ferguson (1901: 43) is closer with: "stipules papillo- or cylindrico-glandular, not often rising above the tomentum."

All the specimens I have seen show the flowers to be monoecious and the racemes androgynous.

The report of *C. suaveolens* by Heller (1895: 58) is based on a specimen of *C. Torreyanus*.

17. C. CORTESIANUS H.B.K., Nov. Gen. & Sp. 2: 83 (quarto), 1817. Campeche, *Humboldt & Bonpland* (P, B?; photo of type seen, UC, US, showing the inscription: Hb. Kunth ex Hb. Humb. 1219).—*Croton trichocarpum* Torr. Bot. Mex. Bound. p. 196, 1859. Matamoros and San Fernando, Tamaulipas (not San Fernando, "Cohahuila" as

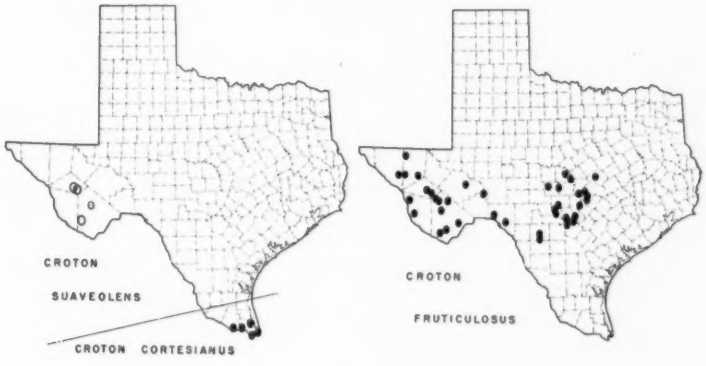
given by Torrey); Torrey cites *Berlandier 1503, 1540, 2244, 3003, 3040,* and *3212 pro parte.*

These shrubs occur in Chiapas, Yucatan, Campeche, Veracruz, San Luis Potosí, Nuevo Leon, Tamaulipas, and the delta of Rio Grande in southern Texas; and apparently also near Mazatlán, Sinaloa. I have seen six collections from southern Texas, four from Cameron County and two from Hidalgo County, all from near the Rio Grande except for *Chandler 7076*, from Rio Hondo, which is located on a distributary of the Rio Grande.

Clover (1937: 93) reports as this species her *No. 190* from Raymondville, Willacy County. I have seen a specimen ticketed as *Clover 190* (MICH) from near Rio Grande City, Starr County; it is clearly *C. humilis.*

18. C. FRUTICULOSUS Engelm. ex Torr., Bot. Mex. Bound. p. 194, 1859. Lectotype of the var. *α pallescens* Muell. Arg. in DC., Prodr. 15(2): 633, 1866, is *Wright exs. 639* (MO?, NY?, G?, US, PH) from western Texas.—*Croton fruticulosus* var. *β fuscescens* Muell. Arg. l.c., p. 634, 1866. San Luis Potosi, *Virlet d'Aoust 143* (G?), and, without locality, *Berlandier 3212 pro parte* (G?, US), the other element included under that number being *C. Cortesianus.*

These are shrubs of limestone or basalt uplands in central Tamaulipas (Sierra San Carlos), San Luis Potosí (fide Mueller Argoviensis), Nuevo Leon, Coahuila and trans-Pecos Texas north to the Organ Mountains of Dona Ana County, New Mexico, and the northward extension of the Guadalupe Mountains in Guadalupe County, New Mexico; and on the Edwards plateau of central Texas as far north and northeast as San Saba and Bell counties; and in Chihuahua (Santa



Eulalia Mountains); and extreme southeastern Arizona (see Wheeler in Kearney & Peebles, 1951: 504).

The species has been reported by Coulter (1890: 49) at "Peña, Duval County, Texas" (now Hebbronville, Jim Hogg County) on the basis of *Nealley 793 = 456* (US); this specimen is correctly determined, but the locality, as given by Coulter, is probably inaccurate.

Clover 1483 (MICH) from Alamo, Hidalgo County, which Clover (1937: 93) reports as *C. fruticulosus*, is actually *C. humilis*.

LITERATURE CITED

BENSON, L. and R. A. DARROW. 1954. The Trees and Shrubs of the Southwestern Deserts. i-x, 1–437 pp. [Euphorbiaceae by L. C. Wheeler]

BENTHAM, G. 1878. Notes on Euphorbiaceae. Journ. Linn. Soc. Bot. 17: 185–267.

BOUGHTON, L. L. 1931. Croton capitatus as a poisonous forage plant. Trans. Kans. Acad. Sci. 31: 147.

CLOVER, E. U. 1937. Vegetational survey of the lower Rio Grande Valley, Texas. Madroño 4: 41–66, 77–100.

COULTER, J. M. 1890. Upon a collection of plants made by Mr. G. C. Nealley, in the region of the Rio Grande, in Texas, from Brazos Santiago to El Paso County. Contr. U. S. Natl. Herb. 1: 29–61.

COULTER, J. M. 1891–1894. Botany of Western Texas. Contr. U. S. Natl. Herb. 2: 1–588. [Croton, 1894: 397–400]

CROIZAT, L. 1940. Thirty-five new species of American Croton. Journ. Arn. Arb. 21: 76–107.

CROIZAT, L. 1942. New and critical Euphorbiaceae chiefly from the southeastern United States. Bull. Torr. Bot. Club 69: 445–460.

CROIZAT, L. 1945. New or critical Euphorbiaceae from the Americas. Journ. Arn. Arb. 26: 181–196.

DEAM, C. C. 1940. Flora of Indiana. 1–1236 pp. [Croton, pp. 637–638]

ENGELMANN, G., and A. GRAY. 1845. Plantae Lindheimerianae, an enumeration of the plants collected in Texas, and distributed to subscribers, by F. Lindheimer, with remarks, and descriptions of new species, &c. Boston Journ. Nat. Hist. 5: 210–264.

FERGUSON, A. M. 1901. Crotons of the United States. Ann. Rept. Mo. Bot. Gard. 12: 33–74.

FERNALD, M. L. 1950. Gray's Manual of Botany, 8th edition. i-lxiv, 1–1632 pp. [Croton, pp. 959–960]

GATES, F. C. 1941. Weeds in Kansas. Rept. Kans. St. Board Agric. 60(243): 1–360.

GLEASON, H. A. 1952. The New Britton & Brown Illustrated Flora of the Northeastern United States. [Croton, vol. 2, pp. 475–476]

HELLER, A. A. 1895. Results of botanical exploration in southern Texas in 1894. Contr. Herb. Franklin & Marshall Coll. No. 1: 1–116.

KEARNEY, TH. H., and R. H. PEEBLES. 1951. Arizona Flora. i-viii, 1–1032 pp. [Croton by L. C. Wheeler, pp. 505–505]

McVAUGH, R. 1956. Edward Palmer, Plant Explorer of the American West. i-xviii, 1–430 pp.

MERRILL, E. D. 1949. Index Rafinesquianus. i-x, 1–296 pp.

MILLSPAUGH, C. F. 1889. Euphorbiaceae Mexicanae. Bull. Torr. Bot. Club 16: 65–67.

MUELLER ARGOVIENSIS, J. 1866. Euphorbiaceae [pars]. DeCandolle's Prodromus 15(2): 189–1286.

ROTHROCK, J. T. 1878. Reports upon the botanical collections made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during the years 1871, 1872, 1873, 1874, and 1875. Report upon United States Geographical Surveys west of the one hundreth meridian in charge of First Lieut. Geo. M. Wheeler . . . vol. VI—Botany. 1–404 pp. [Euphorbiaceae by Dr. Geo. Engelmann, pp. 242–248]

SMALL, J. K. 1903. Flora of the Southeastern United States. i-xii, 1–1370 pp. [Croton by Ferguson, pp. 693–698]

SAVAGE, S. 1945. A Catalogue of the Linnaean Herbarium. i-xvi, 1–225 pp.

STANDLEY, P. C. 1920–1926. Trees and Shrubs of Mexico. Contr. U. S. Natl. Herb. 23: 1–1721. [Croton, 1923: 610–620, 1926: 1669]

WHEELER, L. C. 1939. A miscellany of New World Euphorbiaceae. Contr. Gray Herb. 124: 35–42.

THE SOUTHWESTERN NATURALIST 3: 204–207 1958 (PRINTED 1959)

CHROMOSOMES OF EAST TEXAS HEDYOTIS (RUBIACEAE)

WALTER H. LEWIS

Stephen F. Austin State College, Nacogdoches, Texas

ABSTRACT. Chromosome numbers for four species of *Hedyotis* are reported: *H. crassifolia* Raf. (2n = 16), *H. corymbosa* (L.) Lam. (2n = 18), *H. nigricans* (Lam.) Fosb. (2n = 18), and *H. australis* Lewis & Moore (2n = 32). Though data are scanty, it appears from these and other numbers that the basic chromosome complements of eight and nine exist for the genus, with nine the more common.

Though there is adequate morphological evidence for a conservative treatment of the genus *Hedyotis* to include the genera *Houstonia* and *Oldenlandia* (Fosberg 1954 and earlier, Shinners 1949), such a treatment lacks a possible avenue of support from cytological data. Not that there now exists information to caste doubt upon this interpretation, but, to be more precise, cytological studies are almost nonexistent, especially for the North American taxa. The chromosome numbers of only one species, *Hedyotis caerulea* (L.) Hook. (formerly *Houstonia*), have been recorded by Stevens (1912) and Fagerlind (1937). The former counted 16 haploid chromosomes from a Connecticut population, while Fagerlind found n = 18 from plants in the Munich gardens of presumably unknown origin. To what extent the basic numbers of eight and nine may be found in the population can only be surmized. Outside of this continent, microsporocyte chromosomes from eight species under *Oldenlandia* have been examined by Hagerup (1932) and Raghavan and Rangaswamy (1941). Their results are distributed in a polyploid series consisting of 2 diploid, 5 tetraploid, and 1 octoploid species with a basic chromosome complement of nine.

Chromosomes of four species, of which three are native and one is introduced to the southern United States, are recorded in the present study. Cytological techniques and materials (immature flower buds) are similar to those described for *Claytonia virginica* (Lewis 1958) and all specimens as listed in Table 1 are in the Stephen F. Austin State College Herbarium.

One of the common spring-flowering annuals of the southern states is *H. crassifolia* Raf. whose individuals have been found with 2n = 16

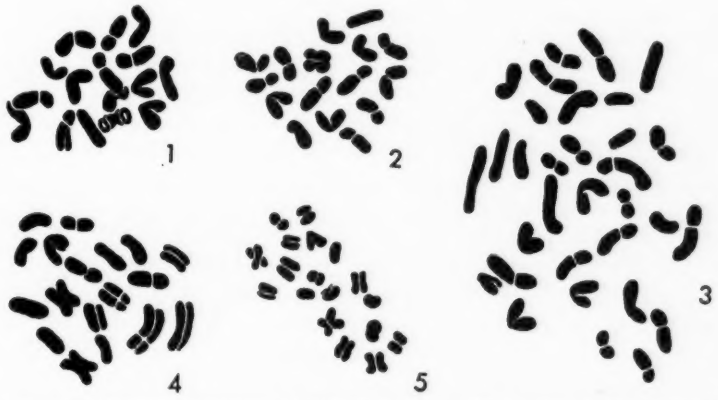
chromosomes (Table 1, Figures 1 & 2). This number is unique not only because it is the smallest yet found in the genus *Hedyotis* and the family Rubiaceae, but because it represents the first substantiated basic chromosome number of eight. To this number can be added the chromosome number of 2n=32 for *H. australis*, a species related to

TABLE 1

Chromosome Numbers of Four *Hedyotis* Species

Species & Locality (Texas)	Collector & Date (1958)	2n	Fig.
H. crassifolia:			
Angelina Co., Lufkin	J. Dies, 2 April	16	
Jasper Co., Bevilport	W. H. Lewis & J. Dies, 8 April	16	
Nacogdoches Co., Nacogdoches*	W. H. Lewis, 28 March	16	1, 2
Shelby Co., Center	M. N. Normand, 8 April	16	
H. australis:			
Angelina Co., Lufkin	J. Dies, 2 April	32	
Nacogdoches Co., Nacogdoches	W. H. Lewis, 28 March	32	3
Shelby Co., Center	M. N. Normand, 8 April	32	
H. nigricans:			
Nacogdoches Co., 3 miles s. Nacogdoches*	W. H. Lewis, 23 July	18	4
H. corymbosa:			
Nacogdoches Co., Nacogdoches*	W. H. Lewis, 14 June	18	5

* Chromosome numbers are recorded from two plants at one locality.



Figs. 1–5: Somatic chromosomes of *Hedyotis* as drawn with a camera lucida at x2350. Fig. 1—*H. crassifolia* (blue-violet corolla color), 2n=16. Fig. 2—*H. crassifolia* (corolla lobes white, tube light pink-violet), 2n=16. Fig. 3—*H. australis*, 2n=32. Fig. 4—*H. nigricans*, 2n=18. Fig. 5—*H. corymbosa*, 2n=18.

and recently distinguished from *H. crassifolia* (Lewis & Moore 1958). These data, together with the unconfirmed count by Stevens (1912) for *H. caerulea*, suggest a polyploid series with eight as a basic chromosome number in the former *Houstonia* annuals.

A third species, *H. nigricans* (Lam.) Fosb., differs from the above small, spring-flowering, annuals by its taller stems, summer-flowering, and perennial habit. Associated with these differences is the chromosome number of $2n=18$ (Figure 4). The basic number of nine is equal to that of the *Oldenlandia* species, and it would seem, at least from cytological evidence, that this former *Houstonia* perennial is more closely related to these taxa than to the *Houstonia* annuals. Fagerlind's (1937) report of $n=18$ for the annual *H. caerulea* would, of course, not fit such an interpretation, but it will be recalled that the general significance of his findings are at present in question.

A recent introduction to the Texas flora is the summer-flowering annual, *H. corymbosa* (L.) Lam. (Lacey 1957). Under *Oldenlandia corymbosa* L., Raghavan and Rangaswamy (1941) reported individuals from India with 18 haploid chromosomes; our material, probably originating in tropical America, has half this number or $2n=18$ (Figure 5). Perhaps a diploid and a tetraploid race exist for this species separable on geographical as well as cytological evidence. A detailed morphological comparison of the two populations would enlighten this infra-specific problem.

The following cytological summary from data now available should not in any way be confused with an attempt to establish a series of broad conclusions for which no preliminary study is equipped.

(1) Within the genus *Hedyotis*, there exist two polyploid series with basic chromosome numbers of eight and nine.

(2) The former species of *Oldenlandia* and perennial species of *Houstonia* have a basic complement of nine chromosomes, whereas the spring-flowering *Houstonia* annuals have a basic number of eight.

(3) *Hedyotis crassifolia* with $2n=16$ has the smallest number of chromosomes yet recorded for the family Rubiaceae.

(4) Both *Hedyotis caerulea* and *H. corymbosa* have two chromosome numbers, though the significance of each in their populations is unknown.

LITERATURE CITED

FAGERLIND, F. 1937. Embryologische, zytologische und bestaubungsexperimentelle Studien in der Familie Rubiaceae nebst Bemerkungen uber einige Polyploiditätsprobleme. Acta Hort. Berg. 11: 195–470.

FOSBERG, F. R. 1954. Notes on plants of the eastern United States. Castanea 19: 25–37.

HAGERUP, O. 1932. Über polyploidie in Beziehung zu Klima, Ökologie und Phylogenie. Chromosomanzahlen aus Timbuktu. Hereditas 16: 19–40.

LACEY, J. B. 1957. *Hedyotis corymbosa* (L.) Lamarck (Rubiaceae) in Nacogdoches, Texas. Field & Lab. 25: 33–34.

LEWIS, W. H. 1958. Three chromosome numbers for *Claytonia virginica* (Portulacaceae). Southwest. Nat. 3 (in press).

RAGHAVAN, T. S., and K. RANGASWAMY. 1941. Studies in the Rubiaceae. I. Journ. Indian Bot. Soc. 20: 341–356.

SHINNERS, L. H. 1949. Transfer of Texas species of *Houstonia* to *Hedyotis* (Rubiaceae). Field & Lab. 17: 166–169.

STEVENS, N. E. 1912. Observations on heterostylous plants. Bot. Gaz. 53: 277–308.

THE SOUTHWESTERN NATURALIST 3: 208–211 1958 (PRINTED 1959)

HEDYOTIS AUSTRALIS (RUBIACEAE), A NEW SPECIES FROM THE SOUTH CENTRAL UNITED STATES

WALTER H. LEWIS

Stephen F. Austin State College, Nacogdoches, Texas

DWIGHT M. MOORE

Arkansas State College, Monticello[1]

ABSTRACT. On morphological and cytological evidence, the small, white-petalled bluet described as *Hedyotis crassifolia* var. *micrantha* Shinners is given specific status as *H. australis*, the epithet *micrantha* having been previously used in that rank.

The population of small, white-petalled bluets has been distinguished from *Hedyotis crassifolia* Raf. as var. *micrantha* Shinners (1950). The typical var. *crassifolia*, known under a number of specific epithets, including *Houstonia pusilla* Schoepf, *H. patens* Ell., and *H. minima* Beck, has a larger, usually blue-violet corolla. In Arkansas, Moore (1952) noted the occurrence of var. *micrantha* in the southern part of the state and later (1958) suggested that the variety should perhaps be raised to specific rank as *Hedyotis micrantha*. This binomial, as a *nomen provisorium*, has no legal standing. Because the same binomial had appeared previously in print we now propose the following.

HEDYOTIS *australis* Lewis & Moore, sp. nov. Based on *H. crassifolia* var. *micrantha* Shinners, Field & Lab. 18: 100. 1950. HOLOTYPE: 7.8 miles southeast of Timpson, Shelby Co., Texas, *Eula Whitehouse 20848* (SMU). *H. micrantha* (Shinners) Moore, Proc. Ark. Acad. Sci. 12: 12, 1958 (*nomen provisorium*). Not *H. micrantha* Hochst. ex Hiern in Oliver, Fl. Trop. Afr. 3: 60, 1877.

This spring-flowering annual is common on roadsides, lawns, and other disturbed areas of Arkansas, Louisiana, and eastern and southern Texas. At most localities both *H. australis* Lewis & Moore and *H. crassifolia* Raf. can be found at anthesis during March and April. Under these circumstances, one might expect the existence of inter-

[1] Now (fall 1958) visiting Professor of Botany at the University of Saigon, Viet Nam.

mediate individuals. Such intermediates have not been observed, however, and the explanation apparently lies with the cytological characteristics of the two taxa. *Hedyotis australis* is a tetraploid with 2n = 32 chromosomes, while *H. crassifolia* has only 16 somatic chromosomes (Lewis, 1958). Hybrid individuals, if they do occur, would be triploid with little chance of survival among the well established and successful parental populations.

In Table 1 is given a statistical summary for five characteristics

TABLE 1

Five Characteristics Differentiating *H. australis* from *H. crassifolia*

	australis			*crassifolia*				
Characteristic	mean	s	range	mean	s	range	t	P
Corolla tube length	1.7	0.3	1.1–2.5	4.0	0.3	2.7–5.2	3.7	<.1%
Corolla lobe length	1.6	0.4	1.0–3.0	3.1	0.7	1.7–4.5	2.9	< 1%
Top of sepals to top of corolla tube	0.04	....	0.0–0.5	2.1	0.7	0.8–4.0	6.5	<.1%
	Per cent			Per cent				
Corolla: white	100			2				
light blue-violet*	0			6				
blue-violet	0			92				
Leaf margin: glabrous	96			6				
few hairs	4			26				
pubescent	0			68				

* Corolla lobes may be white or tinged blue-violet, with a light blue-violet or pink-violet tube.

based on 50 individuals selected at random from each species. The short corolla tube and lobes, and the distance from the top of the sepals to the apex of the corolla tube for *H. australis* is in sharp contrast to the greater length of these for *H. crassifolia*. The probability that the characteristics are different is given and the results of P = <.1, <1, and <.1 per cent emphasize their discontinuity. No corolla colour other than white has been found for *H. australis*. Though white as well as light shades of blue-violet and pink-violet are known for the corolla colour of *H. crassifolia*, these are rare (8%) compared to the number of individuals known with a distinct blue-violet colour (92%). A second qualitative characteristic useful in distinguishing the populations is the presence or absence of hairs along the leaf margins. Margins are glabrous (96%) or rarely somewhat pubescent (4%) in *H. australis;* those of *H. crassifolia* are occasionally glabrous (6%) though commonly pubescent (94%). When present, these marginal hairs are

rather stiff, short, and broad-based. Measurements were taken for the maximum stem lengths, which showed that *H. australis* ($\bar{x}=5.1$, $s=\pm 1.8$ cm.) and *H. crassifolia* ($\bar{x}=7.5$, $s=\pm 3.0$ cm.) with a $P=>5$ per cent are not significantly different for this characteristic. By these five easily used morphological characters, *H. australis* can be differentiated from *H. crassifolia*. The chromosome number of the former is $2n=32$, the latter $2n=16$.

As mentioned above, *H. australis* is known from three states, viz., Arkansas, Louisiana, and Texas. There is little doubt that the species occurs in a number of surrounding states including Mississippi, Oklahoma, and Tennessee, though no specimens have been observed from these areas.

SPECIMENS EXAMINED

ARKANSAS. Ashley Co.: 4 miles east of Hamburg, *D. M. Moore 58–62* (UARK). Bradley Co.: Warren, *Moore 58–29* (UARK). Calhoun Co.: 10 miles east of Camden, *Moore 57–90* (UARK). Clark Co.: north of Arkadelphia, *Moore 56–24* (UARK). Drew Co.: Arkansas A. & M., College Heights, *Moore 58–18* (UARK). Miller Co.: Texarkana, *Moore 520–251* (ASTC). Pope Co.: 5 miles north of Russellville, *G. B. Van Schaack 3564* (SMU). Pulaski Co.: north of North Little Rock, *Moore 56–25* (UARK). Union Co.: north of Maryville, *Moore 57–97* (UARK).

LOUISIANA. Beauregard Par.: 8.5 miles south-southwest of De Ridder, *L. H. Shinners 25832* (SMU). De Soto Par.: 12 miles northeast of Mansfield, *Shinners 18129* (SMU). Red River Par.: Coushatta, *Shinners 18120* (SMU). Sabine Par.: 5.2 miles west-southwest of Many, *Shinners 25851* (SMU). Tangipahoa Par.: 9 miles east of Ponchatoula, *Shinners 17978* (SMU). Vernon Par.: Rosepine, *P. L. Coryell 739* (SMU).

TEXAS. Angelina Co.: 2.6 miles southeast of Diboll, *Shinners 18198* (SMU); Lufkin, *J. R. Dies*, 1 April 1958 (ASTC). Cherokee Co.: 2 miles north of Mt. Selman, *Shinners 18190* (SMU). Harrison Co.: 1.1 miles southeast of Harleton, *Shinners 18162* (SMU). Liberty Co.: 1 mile west of Cleveland, *Shinners 25807* (SMU). Nacogdoches Co.: 4.6 miles northwest of Melrose, *Shinners 18155* (SMU); S. F. A. campus, Nacogdoches, *W. H. Lewis*, 29 March 1958 (ASTC). Panola Co.: west side of Carthage, *Shinners 18171* (SMU). Polk Co.: 3¼ miles south of Corrigan, *V. L. Cory 53933* (SMU). Rusk Co.: 2½ miles northwest of Henderson, *V. L. Cory 54887* (SMU). Sabine Co.: 5.1 miles east-northeast of Milam, *Shinners 25863* (SMU). Shelby Co.: Center, *M. N. Normand*, 8 April 1958 (ASTC); 11.5 miles northeast of Center, *Shinners 18131* (SMU); 7.8 miles southeast of Timpson, *E. Whitehouse 20848* (SMU) (HOLOTYPE). San Augustine Co.: 5 miles north-northwest of San Augustine, *Shinners 25870* (SMU). Upshur Co.: 3 miles south of New Diana, *Shinners 18158* (SMU).

LITERATURE CITED

LEWIS, W. H. 1958. Chromosomes of East Texas *Hedyotis* (Rubiaceae). Southwest. Nat. 3: 204–207.

MOORE, D. M. 1952. Additional new records for the Arkansas flora. II. Proc. Ark. Acad. Sci. 5: 91–93.

———. 1958. New records for the Arkansas flora. IV. Proc. Ark. Acad. Sci. 12: 9–16.

SHINNERS, L. H. 1950. *Hedyotis crassifolia* Raf. var. *micrantha* Shinners, var. nov. Field & Lab. 18: 100.

THE SOUTHWESTERN NATURALIST 3: 212–237 1958 (PRINTED 1959)

NOTES

THE MEDITERRANEAN LICHEN PARMELIA PERRETICULATA IN CENTRAL TEXAS.—**Parmelia perreticulata** (Räs.) comb. nov. (*P. duboscqii* des Abb. var. *perreticulata* Räs., Ann. Bot. Soc. Zool. Bot. Fenn. 20(3): 3. 1944) has been collected a number of times in Italy by Camillo Sbarbaro, who usually identified it erroneously as *P. sbarbaronis* B. de Lesd. *Parmelia sbarbaronis* reacts C—, K + yellow (stictic acid), and *P. duboscqii* is esorediate.

The writer has recently identified a collection from Bell County, Texas, as *P. perreticulata* by comparison with specimens supplied by Dr. H. des Abbayes and closely adnate to the bark of a leguminous tree, with narrow elongate lobes 2–3 mm. wide, marginal soredia, and a strongly reticulately wrinkled upper surface. The Italian plants usually occur on rock and mosses. All plants tested chemically so far (including those listed below) contain lecanoric acid (medulla C+ blood red), unusual for a narrow lobed *Parmelia*. This is the first record of an endemic Mediterranean Parmelia occurring in the southwestern United States.

Specimens examined: United States: On tree in pasture, Rogers, Bell County, Texas, *M. E. Hale* 5319 (US). Italy: Spotorno, Liguria Orient., *C. Sbarbaro*, January 1934 (US); Zorre, Spotorno, Liguria, *C. Sbarbaro*, November 1935 (US); Menepego, Spotorno, Liguria, *C. Sbarbaro*, February 1952 (US); Gioja, Spotorno, Liguria, *C. Sbarbaro*, December 1951 (US).—*Mason E. Hale, Jr., Smithsonian Institution, Washington 25, D.C.*

★ ★ ★ ★ ★

TRANSFERS FROM ANDROPOGON TO BOTHRIOCHLOA (GRAMINEAE).—With the exception of U.S. authors, grass systematists of the world almost universally have come to recognize Hackel's *Amphilophis* section of *Andropogon* as a separate genus, *Bothriochloa*. The following name transfers are proposed in the belief that the group is sufficiently distinct to warrant generic recognition, and that this concept will eventually find general acceptance in this country.

BOTHRIOCHLOA SACCHAROIDES (Swartz) Rydb. var. **longipaniculata** (Gould), comb. nov. *Andropogon saccharoides* var. *longipaniculatus* Gould, Field & Lab. 23: 17–19. 1955.

BROTHRIOCHLOA SACCHAROIDES var. **torreyana** (Steud.), comb. nov. *Andropogon torreyanus* Steud., Nomencl. Bot. ed. 2, 1: 93. 1840.

BOTHRIOCHLOA SACCHAROIDES var. **pulvinata** (Gould), comb. nov. *Andropogon saccharoides* var. *pulvinatus* Gould, Madrono 14: 25–26. 1957.

BOTHRIOCHLOA BARBINODIS (Lag.) Herter var. **perforata** (Trin.), comb. nov. Andropogon perforatus Trin. ex Fourn., Mex. Pl. 2: 59. 1886.

BOTHRIOCHLOA **reevesii** (Gould), comb. nov. *Andropogon reevesii* Gould, Madrono 14: 20–21. 1957.

BOTHRIOCHLOA **palmeri** (Hack.), comb. nov. *Andropogon saccharoides* ssp. *leucopogon* var. *palmeri* Hack. in DC., Monogr. Phan. 6: 496. 1889.

BOTHRIOCHLOA **hybrida** (Gould), comb. nov. *Andropogon hybridus* Gould, Madrono 14: 21–22. 1957.—*F. W. Gould, Department of Range & Forestry, A. & M. College of Texas, College Station.*

ARABIDOPSIS THALIANA (L.) HEYNHOLD (CRUCIFERAE) INTRODUCED IN NORTHEASTERN TEXAS.—This rather insignificant Eurasian annual is now widespread in both the eastern and far western United States. Small's *Manual* (1933) reported it as occurring from Georgia to Arkansas; Hopkins in 1943 cited it from McCurtain Co. in extreme southeastern Oklahoma (Rhodora 45: 268–269; date of collection not given). Its appearance in eastern Texas was entirely to be expected; it is only surprising that the plant was not observed there sooner. The following collection shows that its westward spread continues: 1 mile south of Ore City, Upshur Co., Texas, *Shinners 26,881* (SMU), 13 April 1958. "Sandy road cut. Petals white." The collection was made in the course of field work subsidized by a grant from the National Science Foundation.—*Lloyd H. Shinners, Southern Methodist University, Dallas 5, Texas.*

★ ★ ★ ★ ★

NEW VARIETAL NAMES IN ARGEMONE (PAPAVERACEAE).—Dr. Gerald B. Ownbey's discerning and thorough "Monograph of the Genus *Argemone* for North America and the West Indies" (Memoirs of the Torrey Botanical Club vol. 21 no. 1, August 29, 1958) is a welcome and much needed contribution, of especial interest to students of the flora of the Southwest and Mexico. I must however take issue with his use of the term subspecies. There are three general ways in which botanists in the United States use it. (I will not call them schools of thought, for remarkably little real thought lies behind them.) One uses subspecies only on the relatively uncommon occasions when it is desired to label a group of varieties. Another uses it for a specially defined taxon intermediate in distinctness (or, as commonly supposed but hardly provable, in phylogenetic differentiation) between species and variety. The third uses it as a "more biological-sounding" or allegedly more precise substitute for the variety of 19th Century botanists (necessarily with some modification due to present knowledge of genetics and ecology). Dr. Ownbey follows the third interpretation, whose spiritual ancestry must be traced back in part to the undesignated trinomial of the American Code, which in turn was a quite superficial imitation of the already utterly uncritical usage of the category of subspecies in dealing with the higher vertebrate animals. On grounds of semantics, logic, and historical precedent, I adopt the first mentioned interpretation. There is also the practical problem of the tens of thousands of new combinations which would become necessary if variety were replaced by subspecies in all groups of plants. For uniformity among the several floras on which I am working, it becomes necessary to emend Dr. Ownbey's infraspecific nomenclature by publishing the following new combinations. The numbers are those under which the respective taxons are discussed in Dr. Ownbey's Monograph.

3b. A. OCHROLEUCA Sweet var. **stenopetala** (Prain) Shinners. *A. intermedia* var. *stenopetala* Prain, Journ. Bot. 33: 364. 1895.

8b. A. SQUARROSA Greene var. **glabrata** (G. Ownbey) Shinners. *A. squarrosa* var. *glabrata* G. Ownbey, Mem. Torr. Bot. Club 21 (1): 62–63. 1958.

10a. A. MUNITA Durand & Hilgard var. **robusta** (G. Ownbey) Shinners. *A. munita* ssp. *robusta* G. Ownbey, ibid. 73–74.

10c. A. MUNITA var. **rotundata** (Rydberg) Shinners. *A. rotundata* Rydberg, Bull. Torr. Bot. Club 29: 160. 1902.

10e. A. MUNITA var. **argentea** (G. Ownbey) Shinners. *A. munita* ssp. *argentea* G. Ownbey, ibid. 83–84.

14b. A. PLEIACANTHA Greene var. **pinnatisecta** (G. Ownbey) Shinners. *A. pleiacantha* ssp. *pinnatisecta* G. Ownbey, ibid. 99.

14c. A. PLEIACANTHA var. **ambigua** (G. Ownbey) Shinners. *A. pleiacantha* ssp. *ambigua* G. Ownbey, ibid. 101–102.

19b. A. CORYMBOSA Greene var. **arenicola** (G. Ownbey) Shinners. *A. corymbosa* ssp. *arenicola* G. Ownbey, *ibid.* 118–120.

21b. A. GRANDIFLORA Sweet var. **armata** (G. Ownbey) Shinners. *A. grandiflora* ssp. *armata* G. Ownbey, ibid. 127.

23b. A. ALBIFLORA Hornemann var. **texana** (G. Ownbey) Shinners. *A. albiflora* ssp. *texana* G. Ownbey, ibid. 141—*Lloyd H. Shinners, Southern Methodist University, Dallas 5, Texas.*

★ ★ ★ ★ ★

ROSA SETIGERA f. ALBA A FORM OF VAR. TOMENTOSA.—Individuals of *Rosa setigera* Michx. may be found with leaflets pubescent on the lower surface (var. *tomentosa* T. & G.) and with leaflets glabrous below or puberulent on the main veins only (var. *setigera*). Within each of these varieties taxonomic recognition has been given to a number of unique individuals having, for example, unarmed stems (var. *tomentosa* f. *serena* (Palmer & Steyerm.) Fern. and var. *setigera* f. *inermis* Palmer & Steyerm.) or white petals (f. *alba* Steyerm.). For the white petalled form, Steyermark (Rhodora 54: 254, 1952) does not indicate whether the leaflets are glabrous or pubescent, though one might assume from his *R. setigera* f. *alba* that it is the typical variety lacking leaflet pubescence except possibly on the main veins, i.e., var. *setigera.* Recently a specimen labelled *R. setigera* Michx. f. *alba* and collected by Dr. Steyermark (7 miles south of West Plains, Howell County, Missouri, number 78797) was examined from the S. M. U. herbarium and I found it to have pubescent leaflets of var. *tomentosa.* At Dr. Steyermark's suggestion his holotype specimen of f. *alba* was borrowed from the Chicago Natural History Museum and it too has pubescent leaflets with the herbarium determination of *R. setigera* var. *tomentosa* f. *alba.* So that no confusion will exist, the published *forma* should be altered to: *Rosa setigera* Michx. var. *tomentosa* T. & G. f. *alba* Steyerm.—*Walter H. Lewis, Stephen F. Austin State College, Nacogdoches, Texas.*

★ ★ ★ ★ ★

CHROMOSOME NUMBERS FOR AMPELOPSIS ARBOREA (VITACEAE) AND LINARIA TEXANA (SCROPHULARIACEAE).—The chromosome numbers of three species of *Ampelopsis* have been previously recorded as $2n = 40$, of which only one taxon, *A. cordata* Michx., is native to North America. The chromosomes of a second North American species, *A. arborea* (L.) Koehne, have been examined from one Texas plant (1 mile west of Denning, San Augustine Co., W. H. Lewis and C. D. Smith, 27 August 1957) and it too has been found with 40 somatic chromosomes.

Of the nine taxa listed under *Linaria* in the Chromosome Atlas (Darlington & Wylie, MacMillan, 1956), six have chromosome numbers of $n = 6$ or $2n = 12$. To this list of diploid species can be added the locally common *L. texana* Scheele which has also been found with 12 somatic chromosomes. The two plants studied were collected at Center, Shelby County (M. N. Normand, 8 April 1958) and at 12 miles south of Nacogdoches, Nacogdoches County (W. H. Lewis, 12 April 1958). All specimens cited above are recorded in our herbarium (ASTC).—*Walter H. Lewis, Stephen F. Austin State College, Nacogdoches, Texas.*

CALLIRHOE BUSHII (MALVACEAE) A VARIETY OF C. PAPAVER.—*Callirhoe Bushii* was described (Robinson and Fernald, 1909:51) from woods of the Ozark region of southwestern Missouri. Fernald indicated that he considered it to be related to *C. Papaver* (Cav.) Gray, differing from that species in having more copious pubescence which is more divergent, more broadly lobed leaves (with the upper ones only slightly lobed), and broader involucel-bractlets.

Martin (1938:460) transferred the taxon to varietal status under *C. involucrata* (T. & G.) Gray. The present author (Waterfall, 1951) in studying the genus in Texas did not treat it, as he saw no material from that state. However, he examined collections of *C. Papaver* from Texas, Arkansas, Louisiana, Georgia and Florida, and observed that *C. Papaver* is one of two species having at least one of the involucel-bractlets inserted 1–3 mm. below the calyx.

The taxon described as *C. Bushii* is represented by material which has at least one of the involucel-bractlets inserted 1–3 mm. below the calyx. An additional characteristic is found in the size of the flower buds just before anthesis. They are often larger than those of *C. Papaver*. This (and the associated large size of the calyx after anthesis) is probably responsible for an herbarium name of Nuttall's. A few specimens with large calyces have been seen from farther southeast, but they are not characteristic of the material seen from that area.

To summarize: there seems to be an Ozarkian population in southwestern Missouri and adjacent Arkansas and Oklahoma which has tendencies toward the characteristics of vestiture, leaves and involucel-bractlets noted by Fernald and mentioned above, and of bud-size observed by Nuttall. These are all variable tendencies, but they are found in this population. Secondly, the remote involucel-bractlet is found in all material referred by the present author to this taxon. This is not characteristic of *C. involucrata*, but of *C. Papaver*. Therefore, it seems better to consider it as more nearly related to the latter species, as Fernald concluded, but as a variety of it rather than as a separate species.

C. PAPAVER (Cav.) Gray var. **Bushii** (Fernald) Waterfall, comb. nov. *C. Bushii* Fernald, Rhod. 11:51. 1909. *C. involucrata* var. *Bushii* (Fernald) Martin, Rhod. 40:460. 1938.

Perennial, usually erect or ascending, sometimes more or less decumbent; varying amounts of pilose spreading hairs in addition to small appressed 4-rayed stellate hairs, sometimes nearly glabrous; blades of cauline leaves usually broader than long (some selected measurements in cm.: 4–5, 5–6, 7–9, 9–9, 9–12), usually deeply lobed into ovate-lanceolate, lance-falcate, oblong or linear-oblong divisions which are often entire but may be sparsely toothed; upper leaves often less deeply lobed than the lower ones, in Oklahoma material sometimes only 3-lobed with the sinuses extending only about halfway into the blade (there has been seen no material matching the type, an extreme with the three upper leaves deeply and irregularly toothed or incised rather than lobed); calyx 15–25 mm. long, the lower one-fourth to one-fifth united; one or two of the involucel-bractlets 1–3 mm. removed from the calyx.

Var. *Bushii* has not been reported previously from Oklahoma. The following material is so referred. CHEROKEE CO.: shaded creek bank 3.6 miles north of Tahlequah on State Highway No. 10, *C. S. Wallis 763*, 15 July 1951. MAYES CO.: wet prairie, 6 miles south of Pryor, *Waterfall* 8196, 7 July 1948; open woods, ¼ mile below Spavinaw Dam, near Spavinaw on State Highway No. 82, *Wallis 3442*, 7 July 1956. SEQUOYAH CO.: shaded creek bank, 2.3 miles north of Marble City (which is 8 miles north of Sallisaw), *Wallis 2397*, 12 June 1955. TULSA CO.: Mohawk Park,

Brodell, 24 June 1934.—*U. T. Waterfall, Department of Botany and Plant Pathology, and the Research Foundation, Oklahoma State University, Stillwater.*

LITERATURE CITED

MARTIN, ROBERT F. 1938. Miscellaneous notes on United States Plants. Rhodora 40: 459–461.

ROBINSON, B. L., and M. L. FERNALD. 1909. Emendations on the Seventh Edition of Gray's Manual. I. Rhodora 11: 33–61.

WATERFALL, U. T. 1951. The genus Callirhoe in Texas. Field & Lab. 19: 107–119.

★ ★ ★ ★ ★

SOLANUM CAMPECHIENSE L. (SOLANACEAE) IN EXTREME SOUTHERN TEXAS.—This species, previously unreported from north of Vera Cruz, is represented in the U.S. National Herbarium by at least ten specimens, including two from Texas. The plants referred here are low, spreading, prickly annuals with blue or purple corollas. Technically they are not very close to any other species occurring in the United States, but they resemble *S. aculeatissimum* Jacq. The latter species differs in its white corollas and non-accrescent calyxes. The following specimens of *S. campechiense* (in addition to the isotype of *S. guanicense*, discussed below) have been examined in the U.S. National Herbarium.

UNITED STATES. TEXAS. Cameron Co.: procumbent herb in black clay soil at Los Fresnos, *Runyon 448*, July 15, 1923. Starr Co.: bottom of Rio Grande below Ringgold, *Havard 43*, August, 1884.

MEXICO. SINALOA. River bed, vicinity of Guadalupe, *Rose, Standley & Russell 14690*, April 18, 1910. TAMAULIPAS. No locality or date, *Berlandier 3196*. VERACRUZ. Vicinity of Pueblo Viejo, 2 km. south of Tampico, *E. Palmer 408*, May 23–31, 1910.

CUBA. SANTA CLARA PROVINCE. Common weed in lanes, more spreading than erect, flowers purple, vicinity of Soledad, *R. A. Howard 4846*, June, 1941. Low herb, edge of lagoon, flowers purple, fruits green, Gavilán, *Howard 6300*, August, 1941.

HISPANIOLA. HAITI. Plaine de l'Artibonite, Gonaives, Desdunes, in mud flats, *Ekman N. H. 3353*. DOMINICAN REPUBLIC, BARAHONA PROVINCE. Sumpfe bei Penon, *Fuertes 1116*, March, 1911.

The name *Solanum campechiense* L., Sp. Pl. p. 187, 1753, may be regarded as based on Dillenius's *Solanum campechiense calycibus echinatis*, Hortus Elthamensis p. 361, t. 268, f. 347, 1732. This, according to Druce & Vines (The Dillenian Herbaria, p. 179, 1907), is based on a specimen at Oxford with the following annotation, presumably by Dillenius: "Dr. Houston's seeds, Elth. 1732." Linnaeus said that the species was from the Gulf of Campeche. He quoted as first synonym his own *Solanum caule aculeato herbaceo, foliis cordatis sinuatis, calycibus aculeatis, "Vir. cliff.* 16. *Hort. Cliff.* 61." The use of the adjective *campechiense* and the illustration in the Dillenian reference make it preferable to give the latter priority with regard to typification. A recent synonym is *S. guanicense* Urban, Symb. Ant. 1: 399, 1899, based on *Sintenis 3918* (isotype at US, holotype was at Berlin), collected along the lagoon toward La Plata, near Guánica, Puerto Rico.

An apparent synonym is *S. acanthifolium* Miller, Gard. Dict. ed. 8, *Solanum* no. 14, 1768, described from plants grown at Chelsea from Mexican seed gathered by

Houstoun. Dunal, who saw specimens of Miller's plants in the Miller herbarium and the Banks herbarium (British Museum), placed the name without question in the synonymy of *S. campechiense* L. Miller's rather scanty description fits our plants well, except for the inflorescence, which he characterizes as of erect umbels at the ends of branches. He gave the origin of his seeds as Vera Cruz, and did not describe from "Campeachy" any *Solanum* remotely like the one under consideration here. Dunal gave the provenance only as the Gulf of Campeche, and did not indicate that he had seen any material specifically from Vera Cruz. Dunal's excellently full description (in DC. Prodr. 13 (1): 312, 1852), apparently based largely on the Miller and Banks specimens, but partly on the Dillenian figure, fits our plants precisely; no other description in Dunal's work does.—*Marshall C. Johnston, Sul Ross State College, Alpine, Texas.*

★ ★ ★ ★ ★

MIMULUS FLORIBUNDUS DOUGL. (SCROPHULARIACEAE) IN ARKANSAS.—Over a period of several years, we have been finding in the Ozark region of northwest Arkansas, on moist soil under seepy limestone ledges, some small annual plants with opposite, petioled leaves, weak, glandular-viscid stems, and pale yellow, slightly zygomorphic, gamophyllous flowers about one cm. long, spotted inside with lavender or magenta. These were evidently in the Scrophulariaceae, but could not be specifically identified by reference to the manuals usually used for this area (Gray, Britton and Brown, Small), (1, 2, 4, 5). They had therefore been laid aside for future attention and study.

While Dr. Hugh Iltis was at the University of Arkansas (1952–55), he decided that our plant was a species of *Mimulus*, and concluded that it was *M. glabratus* var. *fremontii* (Benth.) Grant, and several sheets (Hugh Iltis and D. M. Moore #5476) were distributed under this name.

The present writer was not satisfied with this identification, but could not do better with the material at hand. Reference to Grant's *Monograph of the Genus Mimulus*, (3), was helpful, but not conclusive. So some of these specimens were taken to some of the larger eastern herbaria for comparison with authentic material. material.

At the Philadelphia Academy of Natural Sciences, the Pennell collection of Scrophulariaceae was particularly helpful and yielded several sheets with which our plants seemed to coincide. These were labeled *Mimulus floribundus* Dougl. *But they were all from western United States—the Rockies or west coastal region, at least 600 miles from our nearest station!* I was reluctant to believe that our Ozark plants were the same as this western species.

In the herbaria of the New York Botanical Garden and Harvard University, similar results were found. Sheets from the west seemed to coincide exactly with our material. These also were labeled *Mimulus floribundus* Douglas. But Grant (3) gives the distribution of this species as "moist places in the mountains from British Columbia to Colorado and California," but she also records collections from two stations in Mexico.

But the final clincher was put on our identification when they were examined by Dr. Robert K. Vickery, Jr., of the University of Utah, who had been specializing in this group of the Rocky Mountain flora, and he gave his confirmatory annotation to our material.

At the time of this determination we had found this plant in five Arkansas counties:—Franklin and Johnson below cliffs near Mulberry River, Newton, at

several places in the Buffalo River Valley, Stone, along Sylamore Creek in the Ozark National Forest, and Washington, in opposite corners,—along Cove Creek in the southwest, and War Eagle Creek in the northeast.

This summer, 1958, pursuing the belief that the plant could be found in similar habitat in some of the other nearby counties, search was made of a similar place, known to the writer, in southwestern Carroll County, and, again, it was found as expected.

All these stations are near streams that head in the Boston Mountains of the Ozark region. It is quite reasonable to believe that further search will show its presence in nearby similar regions, even in adjacent Oklahoma and Missouri.

The accompanying maps show the stations in the six Arkansas counties where

Mimulus floribundus Dougl. has now been found, and the western states where it has been reported either by Grant (3), or in the various herbaria.

Naturally many questions arise. Is it possible that this disjunct distribution of *Mimulus floribundus* in the Arkansas Ozarks and the Rocky Mountains indicates that there was once a continuous favorable habitat across the western half of the continent? There are some botanists who might hold to such a theory. Can it be possible that the plant has long been an over-looked species of the Ozarks, whence it has been transported westward to the relatively younger Rockies with resultant wide distribution there? Or has it been moved into the Ozarks from the western center of distribution? It's small size, and particular places of growth raise questions on the manner of migration. Birds?—They seldom migrate in an east-west direction. Streams?—The Arkansas River flows from Colorado, but does not go up into the Ozarks. Winds?—The sheltered habitats under rock ledges seem to rule out this as

a means of travel. Speculation will doubtless continue but an answer may be very difficult to find.—*Dwight M. Moore, Arkansas State College, Monticello.*

LITERATURE CITED

1. FERNALD, M. L. Gray's New Manual of Botany. 8th Ed. American Book Co., New York.
2. GLEASON, H. A. 1950. New Britton and Brown Illustrated Flora. New York Botanical Garden, N.Y.
3. GRANT, A. L. 1925. A monograph of the genus *Mimulus*. Ann. Mo. Bot. Gard. 11: 99–388.
4. SMALL, JOHN K. 1913. Flora of the Southeastern United States. Publ. by author, New York.
5. SMALL, JOHN K. 1933. Manual of the Southeastern Flora. Publ. by author, New York.

★ ★ ★ ★ ★

DYSSODIA **Gentryi** M. C. Johnston (COMPOSITAE), new species.—Annua glabra tenuis erecta 11–13 cm. alta pauciramosa. Folia sessilia simplicia linearifiliformia 5–13 mm. longa (suprema multo minora) mucronulata minute glandulosa. Capitula pauca. Involucra turbinata vel subcampanulata ca. 6 mm. alta ecalyculata. Phyllaria 8 biseriata, exteriora marginibus minute glandulosa, interiora latiora eglandulosa. Flores flavi, radiati 5–8 ca. 6 mm. longi, discoidei ca. 25 et 3.0–3.5 mm. longa. Pappus squamellosus paleis biseriatis, exterioribus muticis 0.5 mm. longis, interioribus apice bifido uniaristatis 2.5 mm. longis.

Glabrous, slender, annual herbs 11–13 cm. high, with erect stems less than 1 mm. thick at base and purplish brown, becoming even more slender and pale yellowish green above, rarely branched once at base, and usually sparingly branched about 5–6 cm. above ground. Leaves alternate, sessile, simple, linear-filiform, mucronulate, fairly soft, bearing tiny glands, 5–13 mm. long, the lowest longest, the highest (on the monocephalous peduncular branches) very short and sparse. Ultimate branches and heads rarely more than 10 per plant, usually 3–4. Involucre ecalyculate, turbinate or slightly campanulate, about 6 mm. high and 4 mm. broad at top. Phyllaries 8, in 2 alternating series, round-keeled; outer with 4–6 minute glands along the free margins; inner broader, glandless; the two series united about ⅝ their length, but the outer bracts have free margins about half their length from apexes; apexes angular-acute mucronulate (the mucronulae minutely fimbriate under 30X-magnification). Corollas yellow; rays 5–8, about 6 mm. long; disk corollas about 25, 3.0–3.5 mm. long. Pappus of 7–10 squamellae in 2 alternating series; outer of muticous paleae about 0.5 mm. long, inner of 3–5 paleae each uniaristate from a bifid apex and about 2.5 mm. long. Achenes slender, about 2.5 mm. long, fuscous, brown-silky-strigose, especially on angles and at base. HOLOTYPE: 10 miles north of Palmito, Durango, Mexico, mesquite-grassland, elev. 5000–5500 ft., *H. S. Gentry 6861*, September 19, 1943 (U.S. National Herbarium).

The species is known only from the type collection, but is distinct enough that I do not hesitate in pronouncing it new. It finds its closest relative in *D. Palmeri* (Greenman) Macbride (*Urbinella Palmeri* Greenman), or in *D. aurea* (Gray) A. Nelson. It takes its name from that of its discoverer, Dr. H. S. Gentry, whose pioneer field work in western Mexico has been the source of herbarium material and ecological information of great value. I am indebted to Dr. Lloyd H. Shinners for supplying the Latin diagnosis.

An apparent isotype is in the herbarium of the University of Michigan, and has been examined through the courtesy of Dr. Rogers McVaugh. It bears the following label data, which would indicate a mixup of labels: "*Zexmenia hispida* Gray, determined by Shreve; erect bushy shrub, shrub-grassland 71 kilometers west of Bermejillo, Durango, *Gentry 6836*, September 18, 1943."—*Marshall C. Johnston, Sul Ross State College, Alpine, Texas.*

★ ★ ★ ★ ★

CARDUUS NUTANS L. (COMPOSITAE), A EUROPEAN THISTLE IN NORTHWESTERN LOUISIANA.—Musk thistle, a coarse, large-headed species, is widespread across the northern United States but of rather local occurrence, as far south as Missouri. In 1939 it was found on a ranch in southeastern Sutton County, Texas (Cory, Madroño 5: 201, 1940). The following collections attest its continued spread in the Gulf Southwest. LOUISIANA. DE SOTO PARISH: 4.6 miles southwest of Gahagan on old U.S. Highway 84, west of junction with state highway, *Shinners 20334*, 8 June 1955 (SMU). "Sandy fencerows; abundant. Plants 1.0–1.8 mm. tall. Corrollas rose-purple." RED RIVER PARISH: 0.8 mile northwest of Armistead, *Shinners 20326*, 8 June 1955 (SMU). "Pasture, sandy silt; about 25 plants, 0.5–1.8 mm. tall. Heads half nodding; corollas rose-purple."—*Lloyd H. Shinners, Southern Methodist University, Dallas 5, Texas.*

★ ★ ★ ★ ★

CARTHAMUS LANATUS L. VAR. BAETICUS (BOISSIER & REUTER) P. COUTINHO (COMPOSITAE): ANOTHER INTRODUCED THISTLE IN CENTRAL TEXAS.—The so-called "Spanish distaff thistle" has been known in California since 1927 (cf. J. T. Howell, "*Carthamus* in California," Leafl. West. Bot. 4: 161–163, 1945), another of that state's many introductions from the Mediterranean region. It has now appeared in Texas: 12 miles south of Brady, McCulloch Co., *Shinners 26293*, 8 June 1957 (SMU). "Gravelly limestone roadside. A few plants (some mowed to ground); specimens from plant 1.2 m. tall. Corollas dull white, anthers straw-color." This locality is on the Edwards Plateau, in the general region from which Mr. Cory reported four other introduced species in 1940 ("Six thistles recently introduced into Texas." Madroño 5: 200–202). It is probable that California supplied us with two of Mr. Cory's half dozen (*Centaurea melitensis, C. repens*), as well as the unwelcome seventh here reported. Three others listed by him were thought to have been introduced in Sutton County with a shipment of hay from California, but only two of them (*Carduus pycnocephalus, Silybum Marianum*) were then known from that state. The third (*Carduus nutans*) had long been known from the northern United States, and appeared recently in northwestern Louisiana (see preceding note). The Texas collection of *Carthamus* cited above was made in the course of field work subsidized by a grant from the National Science Foundation.—*Lloyd H. Shinners, Southern Methodist University, Dallas 5, Texas.*

★ ★ ★ ★ ★

PLASTIC MATERIALS FOR SIMPLIFIED TENT AND FUNNEL TRAPS.—For the past half century tent traps and funnel traps have been utilized for the collection of emerging aquatic insects. Recent reviews of the literature have been made by Wohlschlag (1950), Jónasson (1954), and Guyer and Hutson (1955). In view of the difficulty of identifying immature aquatic insects and the relative ease of adult identification it is rather surprising that such a large literature of bottom

fauna, per se, has been produced while the published results of tent and funnel trappings remain relatively obscure.

Recently, the work of Guyer and Hutson (op. cit.) has given new impetus to this particular line of investigation by demonstrating the statistical reliability of the two general methods of trapping.

The principal objections to using traps apparently have been the time consumed, expense of construction, cumbersomness of transport and relative fragility once the trap is in operation. The traps herein described largely overcome these objections through the use of inexpensive plastic materials which are easy to manipulate during construction and do not deteriorate rapidly under exposure. Also, because of the transparency and lack of excessive supporting structures, these traps greatly reduce the possibility of insects avoiding them because of shadows, as is found when the construction material is cloth or wire screen.

TRAP A (Figure 1). This trap has been designed as an underwater funnel trap. It can be operated either floating or submerged. On a very popular fishing lake it was found to operate best when set on the bottom, thus avoiding the boats of fishermen.

The cone of the trap is made of 2 mil natural colored polyethylene plastic film supplied by Peter and Company of Louisville, Kentucky. It is supported at the bottom by a galvanized iron wire ring which has a diameter of 13.5 inches, enclosing a 1 square foot area. The height of the cone is 13.4 inches. (The plan for a plankton net cone was given by Welch, 1948.) The collection receptacle, a 250 milliliter erlenmeyer flask, is attached to the polyethylene cone by rubber bands or with a string tied in a bow knot in order to facilitate releasing the flask from the cone. The cone itself is cut from sheet film and the edges sealed with an ordinary laundry iron turned to a low heat.

In operation the trap is dipped beneath the lake surface, allowing water to enter the funnel and flask. When the flask is about ⅓ full the trap is lowered to an upright position thus enclosing a large pocket of air in the top of the flask. If the trap is used as a surface floating trap this air is sufficient to buoy it. If the trap is to be used completely submerged then the bottom ring is weighted and the trap lowered to the bottom. Its position is marked by a surface marker attached to the flask by means of a monofilament nylon fishing line and wire halter. A single joint of bamboo fishing cane makes an excellent marker since it is inconspicuous and not apt to be an object of curiosity and possible examination by people accidently encountering it.

When the trap is raised after a set has been completed, the upward movement causes the surrounding water to be deflected, pressing the sides inward. This effectively closes it, as has been demonstrated repeatedly by having close agreement between the number of adults and pupal exuviae in the flask.

When the trap is brought to the surface (but not removed from the water) it is closed with a rubber stopper which is inserted up inside the cone into the neck of the flask thus enclosing the water which was introduced during its setting. The flask can then be removed, inverted and the flying insects removed with an aspirator or it can be placed in a separation funnel rack or similar receptacle for transport back to the laboratory. Then, if the experiment warrants it, another flask can be substituted and the trap reset. To evaluate the diel cycles of midges such a procedure has been followed. If the insects were not aspirated in the field, they are etherized or killed with carbon tetrachloride introduced around the stopper. Following inactivation or death of the insects they can be removed from the flask by pouring the

enclosed water into fingerbowls. If sufficient care is exercised during handling virtually none of the specimens will be "wet down".

TRAP B (Figure 2). This trap is designed as a tent trap for the collection of emerging insects above beds of aquatic vegetation. It can be used as a funnel trap but because of the stiffer material from which it is constructed it is more cumbersome to handle. The trap funnel is made of 2 mil, transparent Poly Flex II plastic which, although flexible, is rather stiff and will retain its shape while supporting a considerable weight. This material, supplied by X. S. Smith of Red Bank, New Jersey, is sold as an inexpensive glass substitute for greehouses and similar structures. The funnel size and lower reinforcing wire are the same as Trap A. This wire ring is laced to the lower edge of the funnel with monofilament nylon line. Since the Poly Flex II plastic is not as readily heat sealed as the polyethylene film its seams are as effectively closed by using office staples and celluloid cement ("airplane cement" or clear fingernail polish). The apex of the cone is fitted up into the neck of the flask and held in position by two hooks inserted into small holes made near the apex of the funnel. These hooks in turn are fastened to the flask halter by rubber bands. The flask-funnel junction is closed with a short length of Scotch brand locker tape No. 245.

In operation the trap is suspended by a wire from a cross arm attached to a pole set into the lake bottom. The trap is hung in such a manner as to have the lower

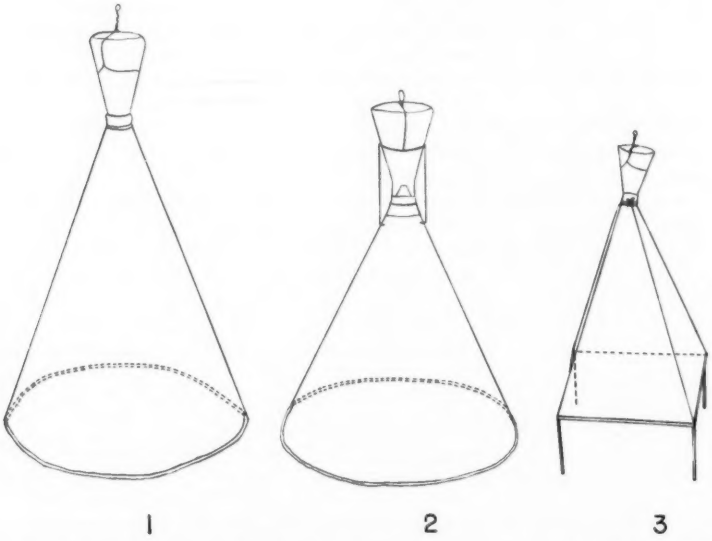


Fig. 1. Trap A. Using small weights this trap can be set on or near the bottom. With weights removed the flask buoys the trap so that it functions as a surface set. Fig. 2. Trap B. A tent trap for the collection of insects emerging from aquatic vegetation. Fig. 3. A pyramidal funnel trap designed for bottom sets. The legs at the corners eliminate interference with water circulation. (These figures were prepared from tracings from photographs and are not to scale.)

2 inches of the funnel submerged. In removing the trap the suspension wire is loosened and the trap slowly forced down into the water, depressing the vegetation before it. The gradual rise of water will cause a displacement upward of the adult insects and floating exuviae. As soon as the neck of the flask is submerged no more air can be lost. The tape seal is then loosened and a u-shaped capillary tube is inserted up into the flask thus permitting more air to escape and the water to rise on up into the lower part of the flask. The funnel is then detached and the flask stoppered. While there is a considerable condensation of moisture within the funnel during the trap's operation, close observation has failed to show a noticeable loss due to the insects being wet down.

TRAP C (Figure 3). The design of this trap is essentially the same as Trap A except that the orifice is formed by a 1 foot square iron frame which gives the net a pyramidal shape. The iron frame used was constructed of ¼ inch round iron rod and had legs attached at each corner. Two leg lengths, 3 and 5 inches, have been used but have not been differentially evaluated. Such legs would be of some significance were the effects of microstratification being studied since the trap, so supported, should not interfere with normal water circulation.

We have found the use of submerged traps of nonporous plastic material to be satisfactory under most conditions. However, in some fertilized ponds 24 hours proved to be too long a period to leave the traps since too many insects accumulated with a resultant wetting down, partial destruction and decay. Under such conditions the traps were examined more frequently. Also, over a bottom with considerable production of gases the bubbles were trapped displacing all of the water from the flask. This caused all the insects to be crowded into the mouth of the flask, resulting in their death. At the same time rising pupae were unable to metamorphose, adding to the decomposition. This gaseous displacement error can be corrected by using larger flasks which can accommodate greater amounts of gases.

We should like to thank Mary Smith Sublette for suggestions and assistance in constructing Trap A. Thanks are due Mr. Burton R. Buckley, a graduate student at Northwestern State College, for suggestions on improvements, construction of traps, and field test of improved models of Traps A and B. Work of the senior author was subsidized by a National Institute of Health research grant, RG-4594 (C), for the study of the relation between the distribution of Tendipedidae and domestic sewage pollution.—*James E. Sublette, Northwestern State College, Natchitoches, Louisiana; and J. S. Dendy, Alabama Polytechnic Institute, Auburn.*

LITERATURE CITED

GUYER, GORDON, and RAY HUTSON. 1955. A comparison of sampling techniques utilized in an ecological study of aquatic insects. Journ. Econ. Entom. 48 (6): 662–665.

JONASSON, PETUR M. 1954. An improved funnel trap for capturing emerging aquatic insects, with some preliminary results. Oikos 5 (II): 179–188.

WELCH, PAUL S. 1948. Limnological Methods. The Blakiston Co., Philadelphia

WOHLSCHLAG, DONALD E. 1950. Vegetation and invertebrate life in a marl lake. Invest. Ind. Lakes & Streams 3 (9): 321–372.

★ ★ ★ ★ ★

A RECORD OF THE OLIGOCHAETE BRANCHIURA SOWERBYI FROM OKLAHOMA.—*Branchiura sowerbyi* was first collected from a tank in the Royal Botanical Society's Garden in London and described by Beddard (1892). Stephenson

(1930) lists its distribution as the Rhone River and several places in Europe and Asia. It has also been recorded twice in South America.

Spencer (1932), who collected *B. sowerbyi* in Buckeye Lake, Ohio, was the first to report it from the United States. Pennak (1953) reports its distribution in the United States as Buckeye Lake and several small streams in Ohio and Michigan. According to Strecker (1954) it has also been found in Illinois, Wisconsin, and Tennessee. Causey (1953) has reported it as being abundant in two lakes in Arkansas.

On July 5, 1957, a single specimen of *B. sowerbyi* was collected by an invertebrate zoology class of Dr. J. T. Self, University of Oklahoma, from a stock watering pond north of Madill, Marshall County, Oklahoma. This worm is characterized by the presence of slender finger-like gills on the dorsal and ventral sides of each segment of the posterior third of the body. It is believed to be a recent introduction to Southern Oklahoma, for aquatic habitats of this part of the state have been rather intensively studied since 1950 by the staff and students of the University of Oklahoma Biological Station located on nearby Lake Texoma. The specimen is preserved in the Invertebrate Collection of the University of Oklahoma Biological Station, Willis.—*Kenneth J. Evans, Zoology Department, University of Oklahoma, Norman.*

LITERATURE CITED

BEDDARD, R. E. 1892. A new branchiate oligochaete *(Branchiura sowerbyi)*. Quart. Jour. Micr. Sci. 33: 325.

CAUSEY, D. 1953. Microdrili in artificial lakes in Northwest Arkansas. Amer. Midl. Nat. 50: 420–425.

PENNAK, R. W. 1953. Fresh-water invertebrates of the United States. Ronald Press. New York. 769 pp.

SPENCER, W. P. 1932. A gilled oligochaete *Branchiura sowerbyi* new to America. Trans. Amer. Micr. Soc. 51: 267–272.

STRECKER, R. L. 1954. A new Ohio locality record for the gilled oligochaete *Branchiura sowerbyi*. Ohio Jour. Sci. 54: 280.

STEPHENSON, J. 1930. The Oligochaeta. Clarendon Press, Oxford. 978 pp.

★ ★ ★ ★ ★

NOTES ON OKLAHOMA SNAILS (GASTROPODA), WITH NEW RECORDS.[1]—Since its inception in 1950 by Lutz, the check list of Gastropoda known from Oklahoma has steadily increased in length. This tendency doubtless will continue as more and more of the opulent habitat-types within the state are sampled. The litter-strewn floors of the deciduous forests in eastern sections of Oklahoma, replete with moisture, molds, yeasts, and lime-containing rocks, form a natural habitat for many species of snails. A large percentage of the streams in this area are spring-fed, slightly alakaline, and support luxuriant growths of aquatic vegetation and tremendous numbers of diatoms and other minute phytoplankters. It is, then, not surprising that most of the larger geophilic gastropods, and by far the most numerous hydrophilic forms, are found in this ecological division of Oklahoma. This type merges in the southernmost part of McCurtain County (southeastern corner of the state) into the palmetto swamps of the coastal plains.

As one travels westward, the terrain, streams, and vegetation progressively change in character from the forested hills to tall grass, to short grass and finally to the

[1] Contribution from the Department of Zoology (No. 273) and the Research Foundation of Oklahoma State University.

arid plains of the extreme west. In westernmost Cimarron County of the Oklahoma Panhandle one encounters a portion of the Rocky Mountain System known as the Black Mesa. This very interesting area possesses extensive canyon systems characterized by a xerophytic flora (Pinon pine-Juniper association). The walls of the canyons display here and there clumps of mountain holly and on the Mesa itself the flora assumes the characters of that found in nearby Colorado (short grasses, *Yucca*, sage, etc.). The gastropod fauna, in some degree, changes with the progressively more arid conditions met with in this east to west moisture gradient.

The streams of central and western Oklahoma are, for the most part, sluggish and silt-laden. Following these streams westward are fingers of deciduous flora, at times simulating conditions of the eastern border. Stillwater Creek, for example, near its confluence with the Cimmaron River, a short distance from Stillwater, is surrounded by such forests. All of these areas are lacking in authoritative systematic surveys and ecological analyses of their molluscan faunas.

The presence of *Discus patulus* (DeShayes, 1830) in Sequoyah County is not surprising since the habitat is nearly identical with that of adjacent Arkansas. Two specimens, found under moist decaying wood on the banks of Sallisaw Creek, agree in characters with those described by Pilsbry (1948) for the forma *edentula* in Arkansas. This collection represents a new record for Oklahoma and apparently the westernmost site recorded for the species to date (BAB, 297). The only other member of this genus found in Oklahoma is *D. cronkhitei* (Newcomb, 1865) which was thought to be restricted to the western tiers of counties. Recently, however, a few specimens were taken in east-central Pottawatomie County (BAB, 296).

A second addition to the Oklahoma fauna, *Probythinella lacustris limafodens* Morrison, 1947, brings the total of forms to 150. Several specimens of this amnicolid were collected on the banks of a small stream in Hughes County by I. E. Wallen, and two specimens near the shore of the Cimarron River in Payne County by me in 1955 (BAB, 299). These were rather confusing finds, for as Berry (1943: 36) observed, species of this genus are supposed to be restricted to the Great Lakes and, even there, are not common. Furthermore, these localities are completely out of character for the described habitat of *Probythinella*, which is said to prefer a sandy substrate, rather clear water and aquatic plants. As stated above, the streams in Central Oklahoma are mostly turbid and in general lack succulent vegetation such as *Nasturtium officinale*. In the clear streams of northeastern Oklahoma *Cincinatia integra* (Say, 1821) is common, with some locality data coming from two central counties (Payne and Pontotoc) and one southeastern county (LeFlore). The only other species in the family Amnicolidae reported from Oklahoma is *Pomatiopsis lapidaria* (Say, 1817) (one specimen from Murray County; three from Cherokee County). A possible explanation for the introduction of *Probythinella* into our fauna might be that these small shells were transported in mud attached to the feet and feathers of migratory aquatic birds. Baker (1945) and Roscoe (1955) considered this method of dispersal of prime importance in the distribution of some aquatic mollusks.

More definitive disseminators, at least of the larger exotic species, are novice aquarists. The only viviparid snail enjoying native haunts in Oklahoma is *Campeloma decisum* (Say, 1817) which is apparently restricted to the mud-bottomed streams in the southeastern quarters of the state. However, two species of the so-called "Tanisha" (Japanese: "Rice Snail"), sometimes referred to as "Mystery Snails," have been introduced into several bodies of water. *Viviparus malleatus* Reeve (= *V. lecythoidus* Bensen), and *V. japonicum* (v. Martens, 1860) were re-

ported by Wallen and Dunlap for the first time in 1954. Branson and Wallen (in press) added another locality for *V. malleatus* and, herein, *V. japonicum* (BAB, 797) is recorded from Lake Ardmore, Carter County. The presence of these snails is doubtless the result of fishbowl-cleansing or purposeful planting. Whether the species will be successful is, however, a moot question, as the colony in Lake Altus seems to have disappeared.

As indicated earlier, most of the larger land snails, such as *Mesodon thyroidus* (Say, 1816), of Oklahoma are distributed in eastern counties. This mycophagous species and a subspecies, *M. t. bucculenta* (Gould, 1848), are found widely distributed in most of the eastern counties, but not in the western counties. The limiting factors are obviously food requirements and moisture. Until the present, the westernmost records for *M. thyroidus* were from the east line of Kay County on the north-central Oklahoma border. As mentioned previously, fingers of deciduous forests (with a few junipers interspersed) are incumbent along the fluviatile regions of the mid-prairies. The upland snails of the east may be found for some distance into regions otherwise forming an insuperable barrier to them. There is such an association on the bluffs near the mouth of Stillwater Creek. A specimen of *M. thyroidus* taken at this site represents the westernmost record I have for this species (BAB, 797). The following are two new locality records: *Mesodon thyroidus bucclenta* from the University of Oklahoma Biological Station, Marshall County (BAB, 707) and *M. t. thyroidus* from Robbers Cave State Park, Latimer County (BAB, 796).

The assistance of Dr. I. E. Wallen in making collections, Dr. J. P. Morrison (U. S. Nat. Mus.) for confirming diagnoses of the species added to the fauna and Dr. G. A. Moore for reading the manuscript is gratefully acknowledged.—*Branley A. Branson, Oklahoma State University, Stillwater.*

LITERATURE CITED

BAKER, F. C. 1945. The molluscan family Planorbidae. Univ. Ill. Press. 530 pp.

BERRY, E. G. 1943. The Amnicolidae of Michigan: distribution, ecology and taxonomy. Misc. publ. Mus. Zool. Univ. Mich. 57: 1–68.

BRANSON, B. A., and I. E. WALLEN. Some further records of snail distribution by counties in Oklahoma. Proc. Okla. Acad. Sci. 36: (in press).

LUTZ, L. 1950. A check list of the land snails of Okla. Proc. Okla. Acad. Sci. 30: 32–35.

PILSBRY, H. A. 1948. Land Mollusca of North America (North of Mexico). Acad. Nat. Sci. Phila. Monogr. 3. (2): I–XLVIII, 521–1113.

ROSCOE, E. J. 1954. Aquatic snails found attached to feathers of Whitefaced Glossy Ibis. Wilson Bull. 67: 66.

WALLEN, I. E., and P. DUNLAP. 1954. Further additions to the snail fauna of Oklahoma. Proc. Okla. Acad. Sci. 34: 76–80.

★ ★ ★ ★ ★

CICADAS CAUGHT BY DRAGON FLIES.—In recently going over some of my field notes of the Oklahoma Biological Survey I found the following, written in the Little River Valley near the U.S. Hy. 70 bridge, northeast of Idabel, McCurtain County, Oklahoma, under date of May 15, 1946:

"The cicada collected was one of many in the trees here. They were recently metamorphosed, for their nymphal cases were numerous about rotten wood. I saw

a large dragon fly capture one and fly away with it—not easily, for the load was heavy. Soon after, a cicada fluttered from a tree to the ground and I picked it up for another specimen. On examination, it proved to have no abdomen whatever and the wound looked very fresh. The cicada was alive and behaved as if not at all discomforted but clung normally to my finger. I wonder if this is the work of the dragon flies, for I saw abundant evidence of a wholesale destruction of the cicadas by some cause, mostly wings on the ground."

In a casual perusal of the larger works on Insecta available to me, I find no reference to any dragon flies feeding on cicadas. Therefore, this incident seems worthy of record. Unfortunately, neither insect was identified.—*Arthur N. Bragg. University of Oklahoma Biological Survey, Norman, Oklahoma.*

★ ★ ★ ★ ★

MISSISSIPPI SILVERSIDES (MENIDIA AUDENS) INSTEAD OF BROOK SILVERSIDES (LABIDESTHES SICCULUS): A CORRECTION.—My report on flood dispersal of brook silversides (S.W. Nat. 2: 173–174) should refer instead to the Mississippi silversides, on the basis of specimens sent to Dr. C. D. Riggs and determined by him as *Menidia audens*. Dr. Riggs notes that "the scales are much larger (predorsals usually 19 instead of 30), the snout is much shorter, dorsal soft rays usually 9 instead of 10 or 11, and the anal soft rays 15 or 16 instead of 20 to 22." Dr. Riggs also kindly supplied the following information regarding the two silversides (in letter of July 22, 1958): "*Labidesthes* has apparently disappeared from Lake Texoma while *Menidia* has become one of the dominant species. The first record of *Menidia* for the lake was one specimen taken in 1953. By 1954 it had become abundant, and at the same time *Labidesthes*, which was previously one of the most abundant species, was becoming quite rare. We have been unable to collect *Labidesthes* in the lake or tributaries for the last two years. We have evidence that *Menidia* has spread in Oklahoma in the same way that you have described for Texas, and has apparently taken over at the expense of *Labidesthes* wherever the latter occurred."—*Walter W. Dalquest, Midwestern University, Wichita Falls, Texas.*

★ ★ ★ ★ ★

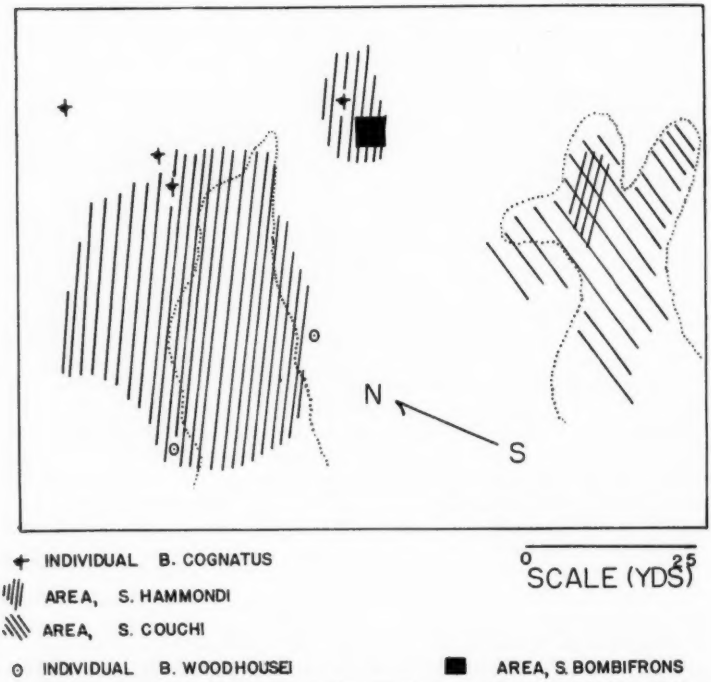
SPECIES DISTRIBUTION IN A MIXED SCAPHIOPUS-BUFO BREEDING CHORUS.—The calling habits of spadefoots have been discussed by several authors, and their mating calls have been objectively analyzed by Blair (Tex. Journ. Sci., 1955, 7: 183–188; and Tex. Journ. Sci., 1956, 8: 236–238). Bragg (Amer. Nat., 1945, 79: 52–72) has emphasized the apparent function of the call as an interspecific isolating and an intraspecific aggregating mechanism. If this explanation of call function is correct, then the mating call must be particularly important in a mixed-species breeding aggregation. Observations on the distribution of individuals in a mixed chorus are therefore of interest and have not been adequately reported previously.

At about midnight on 11 June 1958 a mixed *Scaphiopus-Bufo* chorus was heard from a distance of about one half mile at Socorro, Socorro County, New Mexico. From the distance the powerful call of *B. cognatus* was most evident, with the calls of *S. couchi* being next in prominence. Both *S. hammondi* and *S. bombifrons* were calling in the chorus, but the call of the latter was detected only after the breeding site was reached. At a distance *S. hammondi* could be recognized most easily by its characteristic slow trill rate. The calls of this species completely masked those of *S. bombifrons*, but this may have been because the latter was less abundant. The calls of *B. woodhousei* were not noticed until the breeding site was closely approached.

When interpreting these observations it is important to remember that the components of the call which seem significant to the human ear may not be those which are important to the female (or male) anuran for which the call is supposedly intended. Van Bergeijk and Witschi (Acta Anat., 1957, 30: 81–91) have shown that the anuran basilar papilla is probably capable of frequency discrimination, but this does not mean that other call components are not important to these animals.

The breeding site was a large grain field (see figure) which was flooded with from one to about 12 inches of water. The water was considerably contaminated with sewage. Air and water temperatures were respectively 16 and 18°C. The field was quite uniform in character except for the variation in water depth. There were two extensive areas in which the water was at least one foot deep. *S. couchi* was entirely limited to the southernmost of these areas. Apparently this spadefoot preferred the deeper water and perhaps the call functioned to aggregate all specimens into one of the two available sites. The "choice" of the southern deep area may merely have been the spot at which the first individual *S. couchi* began to call (Neill, Herpetologica, 1957, 3: 185–187, described a similar situation for *S. holbrooki*).

S. hammondi was the most abundant spadefoot present, and individuals were



A flooded grain field in Socorro County, New Mexico supporting a mixed *Bufo-Scaphiopus* chorus on 11 June 58. Dotted lines enclose areas which were under about one foot of water. The remainder of the field was covered with several inches of water.

concentrated in the northern deep-water area with one small aggregation in a central, shallow region, and another in the midst of the *S. couchi* chorus. It is tempting to suggest that both *S. couchi* and *S. hammondi* have deep-water breeding preferences (contrary to Bragg's impression that they prefer shallow water), and that the mating calls were serving to isolate the two species into the two available areas. However, the chorus was under observation for more than two hours, and there seemed to be no movement of the small *S. hammondi* aggregations toward the large northern congress.

The few *S. bombifrons* present were closely aggregated in a small shallow region, and were integrated with one of the isolated *S. hammondi* choruses. The two species of *Bufo* were not in full chorus. It is of interest, however, that the individuals which were present were all in the same general vicinity.

In the Socorro congress much of the potential breeding area was not occupied by any anuran species, and when two apparently equally favorable areas existed a given species tended to aggregate into only one of these regions. It seems that individuals were concentrating in one spot not only because it was favorable physically, but also because there were other conspecific individuals present. The most obvious stimulus for distance-recognition of a conspecific chorus is the mating call. There is no indication that the presence of one anuran chorus had an inhibitory effect on the aggregation of another species in the same area.—*Wayne H. McAlister, University of Texas, Austin 12, Texas.*

★ ★ ★ ★ ★

THE CLASPING REFLEX OBSERVED IN JUVENILE SPADEFOOTS.—*(Scaphiopus).* In mid-May, 1957, I collected tadpoles of the plains spadefoot (*Scaphiopus bombifrons* Cope) which metamorphosed near June 1. The juveniles were left in a metal container, half filled with earth above which a light was placed for the attraction of insects upon which they could feed.

On August 15, between three and four inches of rain fell in two storms, flooding the container. At 9:15 that evening I found these small juveniles (mean snout-vent length = 31.6 mm., range 28–38 mm.) in typical clasping pairs on the water. They were quite vocal also, some squeaking loudly as others attempted clasping.

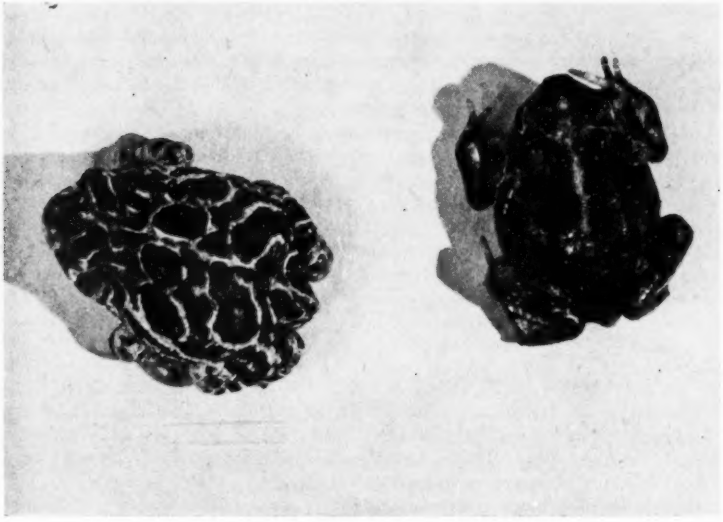
The small size, absolute lack of excrescences on the toes, and the high-pitched "protesting note" indicated that these were in no sense sexually mature. The observations therefore indicate that the clasping reflex in this species is well developed in juveniles and its expression called forth by the same factors as in the adult—flooding from rainfall.—*Arthur N. Bragg, Biological Survey, University of Oklahoma, Norman.*

★ ★ ★ ★ ★

A MELANISTIC TENDENCY IN THE GREAT PLAINS TOAD, BUFO COGNATUS.—During July and August, 1957, I collected and marked 1500 juveniles of *Bufo cognatus* Say in and near Norman, Cleveland County, Oklahoma. A small number, probably less than 10%, of these, were exceptionally dark, although otherwise typical of their species. Most were secured in an agricultural area of one square mile but a few were collected elsewhere. One was taken approximately four miles from the above-mentioned mile square area. In handling literally thousands of specimens of *B. cognatus* of all ages in the region of Norman and other parts of Oklahoma during the past twenty years, I have never before seen this coloration.

The only other distinctive feature of these specimens was that all were smaller than typically colored ones with them. Since both types had emerged from pools

formed by exceptionally heavy rains during the spring, this probably indicates only that they were among the last to transform. Because of this, I suspected that they were siblings and probably the result of a mutation in one or both parents. However, it seems quite doubtful that some individuals derived from a single clutch of eggs should have moved as much as four miles from the area where most were found and which presumably was near their natal pond. Yet they might have done so;



and this seems more likely than that the same mutation should have occurred, practically simultaneously, into two or more parental toads in separate areas.

During May, June and July, 1958, I have again found several of these little dark toads within the square mile area mentioned. They have grown well and appear as active and healthy as their normally colored fellows. The accompanying figures were made from a single exposure to show the contrast in two toads of comparable size. The individuals shown were collected within a quarter mile of each other in May, 1958 within the square mile area mentioned. They are, therefore, approximately one year old juveniles. Both are females.

I am indebted to Mr. Marlin Dobry, one of my students, for the photograph.—*Arthur N. Bragg, The Oklahoma Biological Survey, University of Oklahoma, Norman.*

★ ★ ★ ★ ★

. THE TEXAS SLIDER (PSEUDEMYS FLORIDANA TEXANA) IN NEW MEXICO.—Bundy (Copeia, 1951:314) reported the occurrence of *Pseudemys floridana texana* on the Bitter Lakes Wildlife Refuge, 12 miles northeast of Roswell, Chaves County, New Mexico; he obtained *Pseudemys scripta elegans* at the same locality. Bundy's specimens constituted the first known record of occurrence of the genus *Pseudemys* in New Mexico and extended the known geographic range of the species *P. floridana* more than 100 miles north-northwestward from an in-

definite locality, in Brewster County, Texas, listed by Brown (An annotated check list of the reptiles and amphibians of Texas. Baylor Univ. Press, 1950: 241).

A specimen of *Pseudemys floridana* (K.U. 15929) in the herpetological collections of the Museum of Natural History, University of Kansas, was obtained at Blue Springs, Eddy County, New Mexico, August 12, 1930, by Mr. L. W. Coghill. Blue Springs lies 15 miles south and 2 miles west of Carlsbad, New Mexico. The K.U. specimen apparently constitutes the second record of the species in New Mexico. The specimen, an adult male (originally identified as *Chrysemys picta bellii*), was noted recently in the course of routine curatorial work; it agrees generally with the description of *P. f. texana* given by Carr (Handbook of Turtles; Comstock; 1952: 312–315). Measurements of the shell in millimeters are: length of carapace, 173; width of carapace, 131; length of plastron, 153; width of plastron, 102; and, height, 63. The stomach and gut of the specimen were filled with finely chopped vegetable matter.

Features that tend to distinguish the Eddy County specimen from specimens of *P. f. hoyi* are: Median notch of maxillary beak wide, flanked by low but distinct, horny teeth; edges of mandibular beak coarsely serrate, median tooth approximately twice height of other teeth and separated from them by diastema; alveolar surfaces of both jaws having sharp, heavy cusps (three on each side above, two on each side below), anterior cusp on each side above separated from other cusps by distinct diastema; orbitomandibular stripe unbroken, continuous with stripe on neck, not connected by vertical bar to mark on tympanum; supratemporal stripe broken, forming oval spot behind eye and widened blotch (15 mm. long) beginning over tympanum and tapering into stripe on neck; plastron indistinctly marked with darker color in a few places on interlaminal seams; light markings on carapace broken and obscure.

It is likely that the specimen came from a tributary of the Pecos River near Blue Springs, probably the Black River. This additional record indicates that *P. f. texana* is probably of regular occurrence in the Pecos River drainage from Trans-Pecos Texas northward at least to central Chaves County, New Mexico, and possibly farther northward.—*John M. Legler, Museum of Natural History, University of Kansas, Lawrence.*

★ ★ ★ ★ ★

THE GROUNDSNAKE, SONORA EPISCOPA, IN ARKANSAS.—Some years ago Philip D. Evans (Copeia, 1940 (1): 53) reported *Sonora episcopa* Kennicott from two counties in southwestern Missouri, presaging its discovery in Arkansas. Actually it was found in northwestern Arkansas in 1945, three specimens having been collected by Dr. R. Weldon Larimore while he was a student at the University of Arkansas. These specimens were placed in a private collection, however, and the record has not heretofore been published.

I wish to thank Mr. Dean Crooks, of Rogers, Arkansas, for bringing these specimens to my attention and for allowing me to study them and make this report. The specimens are retained in his private collection. I also wish to thank Dr. Dwight Moore, Emeritus Professor of Botany, for accompanying me to the region and pointing out the precise locality that the specimens were collected.

The point of capture is three miles south of Sulphur Springs, Benton County, Arkansas. The area is a stream valley that has been cut through the Boone formation into the underlying Chattanooga shale. Steep bluffs and overhanging cliffs are formed by the differential weathering of the hard limestone at the base of the Boone and the soft shales below. The three specimens collected by Dr. Larimore

were under stones in an open, southwest-facing slope on the east side of the valley. A fourth specimen of *Sonora* was found on a southeast-facing slope about one mile north of the original locality on the opposite side of the valley. It was under one of the slabs of limestone that litter the steep slope below the limestone ledge. At botl. localities the hillside is dry and relatively bare, with scattered juniper trees and little other vegetation.

The snakes collected by Mr. Larimore include a subadult male with a body length of 140 mm. and a tail length of 30 (Crooks specimen "a"), a female with a body length of 208 and tail length of 43 (Crooks specimen "b"), and a juvenile female with a body length of 108 and a tail length of 24 (Crooks specimen "c"). The larger female ("b") is adult, as evidenced by a mass of eggs in the ovaries. The specimen collected by me (UADZ 1745) is a male with a body length of 180 mm. and a tail length of 44. The large hemipenes suggest that it is an adult.

Except for the juvenile female (Crooks specimen "c"), which has 15 well-defined bands on the body and four tail rings, the snakes are unicolor with a dark spot of varying size on the frontal and parietal scutes and a dark nuchal band six dorsals long and extending laterally to row IV that is three dorsal rows behind the parietals. The recently collected specimen (UADZ 1745) in life showed a ventral color of very light cinnamon, the first two dorsal rows, cinnamon, rows III to V somewhat grayer, and rows V to VIII brownish red.

All of the specimens have entire nasals, 1 + 2 oculars, and divided anal plates. The loreal is present except in one (UADZ 1745), and the temporals are 1 + 2 except one (Crooks specimen "c") has a small scale wedged above the first temporal on the right side. This same specimen has 6–6 supralabials, while the count is 7–7 in the others; the infralabials are 6–6 in three specimens, 6–7 in one (Crooks specimen "b"). The ventral counts are 138 and 142 in the males, and 151 and 152 in the females when counted according to the method previously described (*vide* British Jour. Herp., 1 (3): 97, 1951), but there are two to four transversely enlarged gulars that might have been included as ventrals by previous workers. The subcaudal counts are 40 in both males, 37 and 39 in the females. The dorsal count is essentially 15 throughout with a few reductions far anteriorly and posteriorly. A typical scale reduction formula (*vide* Copeia, 1951 (2): 131) for a specimen (Crooks specimen "b") is:

$$16\frac{7+8(4)}{}15\frac{2+3(148)}{}14\ (152).$$

In the one specimen where the maxillary dentition was examined (Crooks specimen "b"), there were 16 teeth without a diastema. The anterior 13 teeth decreased in size toward the posterior part of the bone; the three posterior teeth were enlarged to somewhat more than twice the size of the adjacent teeth, and had shallow lateral grooves as described by Stickel (Proc. Biol. Soc. Washington, 56: 112, 1943).

These specimens, therefore, agree well with those described by Evans (*ibid.*) from Missouri except that the caudals in the males are one fewer than observed by him and the ventrals of the males are two to six fewer. The disagreement in ventral counts is probably somewhat influenced by differences in the method of making the counts. It is also interesting that all of the Missouri specimens had 11 or more dark bars, only one of those from Arkansas having more than one. The Arkansas specimens also agree well with the form called *Sonora e. episcopa* Kennicott by Stickel (*ibid.* and *vide* Copeia, 1938 (4): 184.). It may be noted, however, that all of the currently recognized species of *Sonora* are very similar morphologically and have allopatric ranges, and it may soon join the growing list of monotypic genera

of American snakes. In such case the form in Arkansas will be called *Sonora semiannulata episcopa* Kennicott.—*Herndon G. Dowling, University of Arkansas, Fayetteville.*

★ ★ ★ ★ ★

AN UNUSUALLY LONG RATTLE STRING IN *CROTALUS ATROX* (SERPENTES: CROTALIDAE).—On November 17, 1955, I killed a large western diamondback rattlesnake (*Crotalus atrox*) in southeastern New Mexico, 12 miles northwest of Carlsbad. A photograph in my possession shows this snake to have been about five feet long. Exact measurements, however, were not recorded, and the specimen was not preserved. Only the rattle, also in my possession, was saved.

This rattle, an incomplete string, is unusual in that it consists of 15 segments. Although authentic accounts of longer rattle strings are on record, one of this length, especially from a wild rattler, is rare enough to deserve mention. Klauber (*Rattlesnakes*, 1956, Vol. 1, pp. 250–260) states that of the many thousands of wild rattlers brought to the San Diego Zoo during the past quarter of a century, the longest rattle string consisted of 16 segments. This was on a sidewinder (*C. cerastes*). Klauber also mentions having examined an apparently authentic string of 19 (originally 23) segments from a western diamondback (*C. atrox*) killed in Texas, and one of 17 segments from an eastern diamondback (*C. adamanteus*) taken in Florida. These are virtual world records for wild rattlers. Captive snakes more often grow long strings, but the usual length for wild snakes is on the order of six to eight segments, and anything over 12 is very unusual.

Nearly all the segments of the rattle recorded in this note are much worn, especially the distal segment, but apparently the string was in no immediate danger of breaking. The segments are large (dorso-ventral width 18–19 mm.), and there is no taper distally. In fact, several of the proximal segments are noticeably smaller than the others. Perhaps this reflects the severe drought which affected the snake's habitat prior to (and including) the year of collection. Other dimensions of the rattle are as follows: compressed length, 85 mm.; normal length, 89 mm.; extended length, 92 mm.

The snake from which this rattle was taken was discovered about noon, lying in the sun at the mouth of a badger hole in which it presumably would have hibernated. The day was cool, with a rather sharp breeze blowing, but the air temperature at ground level in the sun was 70° F. The snake appeared to be very sluggish, for it neither coiled nor rattled, even though I walked by within a few feet of it several times before I saw it. I had a distinct impression that this snake's coloration was unusually dark, but the photograph does not seem to show this.—*Howard Campbell, Dept. of Game and Fish, Albuquerque, New Mexico.*

★ ★ ★ ★ ★

RECORD OF THE HERMIT WARBLER, *DENDROICA OCCIDENTALIS*, IN NEW MEXICO.—In a small collection of unstuffed, flat skins stored as an adjunct to the main collections in the Museum of Zoology of the Department of Biology at New Mexico College of A. and M.A., State College, New Mexico, there is a skin of a Hermit Warbler (*Dendroica occidentalis*). The specimen is unsexed, is in first fall plumage, and was taken at 10,000 feet on Sawyer's Peak, above Kingston, Sierra County, New Mexico, on August 11, 1904, by O. B. Metcalf. The specimen seems to be also the first ever taken in New Mexico, and brings to four the known total taken in the state (see Phillips, Condor, 1947, 49:122, for summary of records). The records seem to show that the Hermit Warbler migrates regularly in low

density through the western half of New Mexico.—*Richard F. Johnston, Museum of Natural History, University of Kansas, Lawrence.*

★ ★ ★ ★ ★

ABUNDANCE OF THE PALO DURO MOUSE *PEROMYSCUS COMANCHE* DURING 1949–1956.—During the course of a study of the *Peromyscus truei* species group of white-footed mice in New Mexico and Texas some information was obtained concerning the abundance of the Palo Duro mouse, *Peromyscus comanche*. Several collecting trips had been made during 1949–1951 by Dr. Jack Herrmann to Palo Duro and Tule Canyons in the Panhandle of Texas, and additional collections were made in the same general areas by the author at irregular intervals from August 1954 through June 1956. Trapping data for *Peromyscus comanche* and other rodents were therefore available for the years 1949–1951 and 1954–1956.

Peromyscus comanche occupies only a restricted range along the prominent Cap Rock Escarpment, the "edge" or "break" of the plains which extends irregularly 200 miles or more from the southeast to the northeast in the Panhandle of Texas (Blair, Contr. Lab. Vert. Bio. Univ. Mich., 24: 1–8, 1943). Locally this species is restricted to saxicolous situations in cedar forests found on the canyon slopes and floors of the region. The brush mouse *(Peromyscus boylei)*, which shows similar ecological requirements, was occasionaly taken in the same trap line with *comanche*, and other rodents captured from the rocky areas but not limited to them were the deer mouse *(Peromyscus maniculatus)* and the Merriam pocket mouse *(Perognathus merriami)*.

Throughout the period of trapping populations of *Peromyscus* were consistently low (Table 1). Thornthwaite (Geogr. Rev., 38: 55–94, 1948) places this area on the eastern edge of the semiarid region with regard to moisture and describes it as Mesothermal B_3 with regard to thermal efficiency. The years 1949–1956 were the driest on record in northern Texas, and it is possible that the scarcity of small rodents in this region may be attributed to drought conditions. The Palo Duro Canyon area was quite dry in March of 1956, but as a result of several heavy showers in previous weeks, the vegetation in the canyon was quite luxuriant in August of 1954 and June of 1956. One day of trapping in March 1956 yielded three *P. comanche*, one *P. boylei* and two *P. merriami*. This catch was obtained from a trap line set in a very rocky situation, whereas lines set on a cedar-covered flood plain and in moderately rocky areas failed to produce any rodents. In June of 1956 traps were set in areas of large, massive boulders in the cedar-mesquite association, and this type of habitat was found to be the most suitable for *comanche*. The three days of trapping resulted in the capture of eight *comanche* and four *P. merriami*. In 1949–1951 Herrmann found *comanche* to be relatively common in and about the Cow Camp, a local name applied to several stone cabins located at the terminus of the paved road into the canyon. However, at this locality in 1954 only one *comanche* was obtained from 240 trap nights. In June of 1956 only *P. merriami* was trapped from this site.

Trapping at Tule Canyon was conducted in an area locally called "The Second Bluff," a small plateau below the rim and approximately 200 feet above the floor of the canyon. Ten individuals were obtained from rocky areas on The Second Bluff in August of 1954 and three from the same area in November of that year. The only other rodent taken in the trap lines with *comanche* was a single *P. merriami*. In 1950–51 Herrmann trapped five *comanche* and five *boylei* from the area.

Patterns of distribution of *Peromyscus* have been discussed thoroughly by Blair

TABLE 1

Sampled Populations of *Peromyscus comanche* and other Rodents from North Texas

Trapping Locality	Date	Trap nights	Catch			
			Peromyscus comanche	*Peromyscus boylei*	*Peromyscus maniculatus*	*Perognathus merriami*
Palo Duro Canyon						
21 Miles SE of Amarillo, Randall County	December 16, 1949	.....	1	..	..	..
	December 26–29, 1949	.....	10	..	..	..
	March 17, 1950	.....	1	1	..	..
	August 4–6, 1954	240	1	..	..	..
	March 31, 1956	120	3	1	..	2
	June 27–29, 1956	363	8	..	..	6
27 Miles SE of Amarillo, Randall County	November 27, 1950	.....	1	..	..	..
	December 2, 1950	.....	1	..	..	..
	January 6–8, 1951	.....	5	..	1	..
17 Miles SE of Washburn, Armstrong County	July 8–12, 1949	.....	1	..	..	..
Tule Canyon						
17 Miles NW of Silverton, Briscoe County	November 28, 1950	.....	1	3	..	..
	December 2, 1950	.....	1	..	..	..
	December 16, 1950	.....	1	2	..	..
	January 5, 1951	.....	1	..	..	..
	January 10, 1951	.....	1	..	..	..
	August 1–4, 1954	960	10	..	..	1
	November 24–25, 1955	120	3	..	..	..

(Adv. in Genetics, 5: 1–41, 1953). The distribution area of *comanche* is quite small when compared with other species of the genus, *e.g.*, the eurytopic distribution of *Peromyscus maniculatus* in North America. Correspondingly the population size of *comanche* seems to be small when compared with other *Peromyscus*. Blair (Amer. Nat., 80: 665–668, 1946) estimated a population of between 9,270 and 17,655 for *Peromyscus polionotus leucocephalus* on Santa Rosa Island off the coast of Florida, and Dice (Contr. Lab. Vert. Gen. Univ. Mich., 10: 1–5, 1939) concluded between one million and five million *P. maniculatus osgoodi* inhabited the Black Hills of South Dakota. The population size of *comanche* undoubtedly does not remain uniform in one area over a considerable period of time, but it is evident that during the six years in which this rodent has been pursued by Herrmann and myself populations have been quite low.

Peromyscus boylei and *P. maniculatus* were the only other cricetine rodents taken with *comanche* in Palo Duro and Tule Canyons, and the scarcity of these rodents tends to eliminate interspecific competition as a limiting factor to population size. Natural predators also appeared to be rare in these areas, and other than raccoon tracks, no signs of larger mammals were seen. Although selection may act through such factors as food availability or disease, no disease or parasites were detected in the individuals trapped, and the food supply seemed sufficient to support the populations examined during the author's three years of sporadic field work. Trapping in early spring or early fall did not indicate an increase in the number of individuals over the summer population, and never were more than two *Peromyscus* taken from one trap line of 40 traps.

The author wishes to express his thanks to Dr. W. Frank Blair for reading the manuscript.—*J. R. Tamsitt, Department of Biology, East Texas State College, Commerce.*

★ ★ ★ ★ ★

NOTES ON THE PORCUPINE *(ERETHIZON DORSATUM)* IN TEXAS.—Taylor and Davis (Tex. Game & Fish Comm. Bull. 27, 1947: 1–79) reported the porcupine *(Erethizon dorsatum)* as widespread over southwest Texas, and from as far east as Kerr and Mason counties, but these mammals have not been abundant until recent years. This paper reports several records from northwest Texas from where the porcupine has been previously unrecorded.

In southwest Texas, Blair (Misc. Publ. Mus. Zool., Univ. Mich. No. 46, 1940: 1–39) reported one specimen from the Davis Mountains, Blair and Miller (Tex. J. Sci., 1949, 1 (1): 1–26) reported one sight record from the Sierra Vieja, Presidio County, and Tamsitt (Tex. J. Sci., 1954, 6 (1): 33–61) reported two sight records from La Mota Mountain in the same county. Herrmann (Tex. J. Sci., 1950, 2 (3): 368–393) had no records of porcupines from the Stockton Plateau.

The porcupine is now fairly abundant in the Davis Mountains. Individuals can be seen with little difficulty in the higher mountain associations and signs are abundant throughout the range down to about 4500 feet. There have been numerous reports of porcupines within the city of Alpine and a few from Marfa located on the plains near the Davis Mountains. C. E. Miller, Jr., reported several recent records in the Sierra Vieja, and Lewis James reported an individual from a ranch near Dryden, on the Stockton Plateau. R. W. Strandtmann reported a road specimen from near Wink, Winkler County.

In northwest Texas, the following reports of porcupines have been received: dead on the road between Ackerly and Big Spring, Howard County (J. R. Tamsitt);

Lubbock, Lubbock County (R. W. Strandtmann); and four miles southwest of Littlefield, Lamb County (Derl Brooks). Another individual from Lamb County was found on the road five and a half miles north of Sudan by the junior author in the Shinoak—Sandsage sand hills association. On the high plains, the junior author recorded one individual from the Hedgecoke Ranch in Armstrong County, 13.5 miles west of the intersection of State Highway No. 284 and Farm Road No. 303.

A number of these records in both southwest and northwest Texas are on the plains some distance from any forest. This seemingly peculiar occurrence of the porcupine has recently been reported also from Arizona by Reynolds (J. Mamm., 1957, 38 (3): 418–419) and from New Mexico by Ivey (J. Mamm., 1957, 38 (4): 490–502).

The apparent increase of porcupines in both range and number in Texas is interesting and may be of considerable biological importance. This is particularly true in that extended drought has tended to decrease some species in both range and numbers during the time porcupines have been expanding. It is doubtful that drought has had a direct effect on the porcupines because the typical high mountain habitats of these mammals have been less affected by drought than the lower mountains and plains.—*William W. Milstead and Donald W. Tinkle, Dept. of Biology, Texas Technological College, Lubbock.*

THE SOUTHWESTERN NATURALIST 3: 238–246 1958 (PRINTED 1959)

REVIEWS

GUIDE TO THE FAMILIES OF MITES. Edward W. Baker, U. S. Department of Agriculture; Joseph H. Camin, The Chicago Academy of Sciences; F. Cunliffe, Pinellas Foundation, Inc.; T. A. Woolley, Colorado State University; and Conrad E. Yunker, University of Maryland. With contributions by R. E. Crabill, Jr., Smithsonian Institution; and G. Nunes, University of California at Los Angeles. Contribution Number 3 of The Institute of Acarology, Department of Zoology, University of Maryland, College Park, Maryland. 242 pages. Copiously illustrated. 1958. $5.00.

The Institute of Acarology, unique in the world, has always been a feather in the cap of its founder, the likeable and energetic Dr. G. W. Wharton. Recently, the Institute has become even more noteworthy by initiating a series of publications. Initial expense for publication was supplied by the National Science Foundation. The University of Maryland has aided with supplemental grants.

The *Guide to the Families of Mites* is Number 3 in the series of proposed publications (Nos. 1 & 2 by George Anastos deal with ticks). It is a slick paper-covered volume, 6 x 9 inches, spiral bound. It is made to open upward rather than to the side, which greatly facilitates its use with the microscope. It is printed by the photo offset method.

The volume contains a chapter on the higher categories of the Chelicerata, by R. E. Crabill, Jr. and an appendix on the Principles of Drawing, by G. Nunes.

The main body of the text consists of keys to the suborders, supercohorts, cohorts, superfamilies, and families. Diagnostic characters and brief descriptions are given for each taxon above family rank. Each family is illustrated by one plate showing a representative member of the family. Genera and species are not mentioned.

The primal author, not only alphabetically but by the amount of time, energy, and material put into the volume, is E. W. Baker, Acarologist for the U. S. Department of Agriculture. Almost all the illustrations and most of the descriptive material is his. The remaining authors contributed keys and some descriptive matter in their particular specialization.

All of the authors are quite aware of certain deficiencies in the keys; as, for instance, one couplet offering choices based only on the female and the next couplet offering choices based only on the male. Unfortunately, such things cannot always be avoided. This reviewer recalls from his student days in Plant Taxonomy that it was utterly impossible to key a composite to the family in Small's Manual of the Southeast Flora. But it did not take long to learn to recognize a composite, and the key otherwise was most helpful. So it is with this manual. There are a few poorly marked turns, but the Guide otherwise is most useful.

There is a selected Bibliography which lists some of the more important works in each suborder. There is no index. The text is in double columns.

The book is dedicated to the late Professor Antonio Berlese, internationally famous

Italian Entomologist and Acarologist.—*R. W. Strandtmann, Texas Technological College, Lubbock.*

A Field Guide to Reptiles and Amphibians of the United States and Canada East of the 100th Meridian. Roger Conant. Houghton Mifflin Company, Boston. 1958. $3.95. pp. xv+366. 62 text figures. 40 plates. Map of eastern North America, 248 distributional maps.

This is No. 12 in the well-known Peterson Field Guide Series. Accordingly, it needs little introduction to anyone who is familiar with preceding field guides of this series such as those to birds, butterflies, animal tracks, etc. This book is somewhat more than a field guide for identifying reptiles and amphibians. The author states that nine times out of ten the reader will have his specimen at hand before he attempts identification and we might add that many times the reader will desire to keep his catch at least for short periods of time once identification has been effected. Conant has wisely included information of interest to the professional and layman alike on the care and handling of reptiles and amphibians both in the field and in captivity. The first four chapters (28 pages) are entitled Introduction, Making and Transporting the Catch, Care in Captivity, What About the Snake-Bite Problem? Each is well-written and the latter three are illustrated with full page photographs showing techniques for handling reptiles (poisonous and non-poisonous) and amphibians. Drawings of tools for catching and transporting, as well as illustrations of living quarters for small captive specimens are included. The author gives a classic retort to his question "What About the Snake-Bite Problem?" in the lead sentence to this chapter: "The best answer is not to get bitten." This answer is supported by the fact that most people are bitten through carelessness. A full page plate illustrates first aid for poisonous snake bite.

Each species or subspecies is treated under the following headings in the text: Identification. Similar Species, Voice (when pertinent), and Range. This book contains the finest color plates (24 full pages) of reptiles and amphibians ever assembled under one cover for $3.95 and the illustrator, Isabelle Hunt Conant, is to be highly commended for her outstanding achievement in reproducing color from live animals. Unfortunately in some cases the diagnostic value of the indicating lines of the Peterson Series has been lost in reduction. Most readers would probably have difficulty in identifying the Texas Map Turtle, *Graptemys versa*, from Plate 8 even though advised to examine closely for the "horizontal or J-shaped line behind eye." The animals depicted in any one plate are all headed in more or less the same direction, the attainment of which must have been a constant exercise in patience for author and illustrator. The hellbenders (Plate 35) and the narrow mouth toads (Plate 39) provide two of several refreshing exceptions which are not in the least considered adversely by this reviewer. A notable handicap to anyone interested in the information that the scientific name conveys is that scientific names are not included with common names on both plates and range maps. This is most regrettable, for common names of reptiles and amphibians are far from stable even though there is some progress toward stability as present. The reader is thus forced to thumb back to the text to inform himself that the Cheat Mountain Salamander is *Plethodon richmondi nettingi* if this information was not conveyed by the salamander's photograph or its distributional map. One can hardly justify this omis-

sion in such a scholarly work, even when the objection is raised that the majority of readers will not be interested in scientific names. It is envisaged that most of the serious students of herpetology who have not mastered the list of accepted common names will write in the scientific names next to the appropriate common name on the plates and range maps.

The author has produced a remarkably current and accurate text simply and graphically written. Several papers published in 1958 or works in press are included in the bibliography, and a form first described as *Eurycea troglodytes* in September, 1957, is included in the text. Phrases or comparisons such as "hairpins" in describing the configuration on the head of some turtles or "a ghostly salamander with toothpick legs" in referring to the Texas Blind Salamander, *Typhlomolge rathbuni* or an "explosive" breeder ready to take advantage of the rains when they come in describing breeding habits of Rio Grande Leopard Frog, *Rana pipiens berlandieri*, contribute to a vivid and readable text which will be envied by many students of descriptive prose.

Taxonomic arrangements are by and large conservative. Higher categories (orders, families, subfamilies) follow A. S. Romer's *Osteology of the Reptiles* and lower categories are in general agreement with the sixth edition of *A Check List of North American Amphibians and Reptiles* by Karl P. Schmidt. Two significant exceptions may be cited. Bull snakes and pine snakes are considered conspecific, thus *melanoleucus* is treated as a polytypic species of the genus *Pituophis*. In chorus frogs of the genus *Pseudacris* we find a major innovation whereby *triseriata* is recognized as a species with several subspecies.

Whether or not the Peterson Field Guide format does justice to the wealth of information contained in this book is subject to serious question. If this book has a prime achievement, it is the almost perfect wedding of a well-written text to excellent illustrations.

The author dedicates his book to the younger herpetologists of America and pays individual acknowledgment to a "small army of herpetologists—professional and amateur" who assisted him in preparing it. Conant has led the "small army" well. Let us sound the trumpet to this fine little (approximately 7½ by 5 inches) book. *Librum commendemus!—J. P. Kennedy, Department of Biology, University of St. Thomas, Houston 6, Texas.*

An Introduction to the Plant Kingdom. Norman H. Russell. C. V. Mosby Company, 1958. XIV plus 340 pages. $5.50.

Although several new textbooks have been published recently for use in elementary botany courses, the large majority of them are essentially alike. They present the materials in basically the same way that botany textbooks have done for decades. Naturally some of the versions have grown in size over previous editions as new information has become available, and in a few instances it is obvious that authors are perplexed at what to include and what to omit. Thus it was refreshing to receive Dr. Russell's book and note that he has been courageous enough to write from a different viewpoint, and has not found it necessary to produce an encyclopedia. As he states in the preface, "The text was written to supply needs of those who teach and the students who pursue one-semester elementary botany courses in which the plant kingdom approach is followed." This kind of approach is not new, but in comparison to traditional and conventional ones, is different. The

book purportedly can be used in introductory botany courses where students have no background in biological concepts, or in those schools where students have a one-semester course in "biology" followed by a course in botany. The "type method" for discussion and illustration of the major groups of plants is used, with the type selected on the basis of familiarity to the instructor, availability, and value in understanding the chief evolutionary concepts. Many of the illustrations are original.

The book is divided into five parts, and each part again divided into short chapters. Part I, deals with the Algae; Part II, Fungi; Part III, Mosses and Liverworts; Part IV, Lower Vascular Plants; and Part V, Flowering Plants. Although the author states that the classification is modern, there is some artificiality and arrangement for convenience in the various chapters. Before launching into the plant kingdom Dr. Russell presents an Introduction. This includes several important topics, such as a brief discussion of the dependence of Man on plants, followed by a fair discussion of how plants got their names, and the origin of the binomial system. A still briefer discussion of the modern biological species concept then follows, using examples from the Angiosperms to illustrate definitions. One might ask if the species-definition given has any validity outside the Angiosperms: For example, in many lower plants where plants do not habitually reproduce in sexually outbreeding systems. Perhaps it would have been better not to introduce any genetic criterion into a species-definition for beginning students. A more serious error was the listing of "taxonomic categories" without an explanation of what taxonomy is all about. This account of the hierarchy of systematic categories probably will prove to be confusing to a beginning student. Might it not have sufficed to emphasize only species, genus, and family names? The introductory chapter closes with a short statement concerning organic evolution. One paragraph is devoted to Charles Darwin and *The Origin of Species*. It was unfortunate that Dr. Russell chose a definition of evolution by Pauli. It is quite inadequate, for there is *not* always a great deal of hereditary variation among individuals of a group (as in asexual forms). The element of chance in evolution is also important, along with natural selection of individuals that are permitted to reproduce. The "struggle for existence" is not do or die, nor is it as dramatic as that old phrase would indicate. The emphasis on the "struggle for existence" is generally overstated, and obscures a more profound understanding of organic evolution. Actually, although Dr. Russell states that teleological explanations have been avoided, to interpret evolution as involving "struggle" suggests or implies conscious striving or directed effort, which is simply not the case in plants and lower animals. The discussion of evolution is somewhat disjointed, probably owing to a desire to simplify the material. It ends with a discussion of fossils and fossil formation. The Introduction is superficial, and attempts to cover too much. The necessity to assume no background on the part of the student renders the chapter of small value for an adequate introduction to the plant kingdom.

The first plant group discussed is the Blue-Green Algae. There is a characterization of these, followed by short accounts of representative genera (*Gloeocapsa*, *Oscillatoria*, *Nostoc*, and "other blue-green algae") with a final paragraph on economic importance. A list of selected references then closes the chapter. The book begins, therefore, with a group that is conveniently placed at the bottom of the sequence of plant groups, although authors have suggested that Cyanophyta are secondarily primitive. It would be difficult to derive the Green Algae from the Blue-Greens. Perhaps the first group considered should be the bacteria. This is a minor point, but one which would not be difficult to present to students with sufficient background.

The pattern once established, the succeeding pages deal with each group in turn in routine style, but with the emphasis on brevity of presentation. Line drawings used to illustrate life histories, structures, etc. are all original, but some of them are inadequate. For example, the diagram of gametophyte and upright sporophyte of *Anthoceros* (page 186) is of practically no value to the student, being unlabeled and poorly drawn. Other drawings, which have come to be traditional for elementary botany texts, such as the archegoniophore of *Marchantia* (page 182), *Selaginella* cone (page 211), the apices of male and female gametophores of mosses (page 171), and the cycad ovule (page 249) leave much to be desired. On the other hand, many of the photographs are excellent and truly striking. The purple cliff-brake fern *(Pellaea glabella)* (page 229), and the partially-open capsule of twinleaf *(Jeffersonia diphylla)* (page 276) are represented in clever and revealing fashion. Drawings, diagrams, and photographs are of uneven quality, ranging from excellent to poor.

Many of the chapters close with a short discussion of the economic importance of the plant group. The chapter on fungi and bacteria ends with an interesting account of the medicinal qualities of fungi, with a quotation from Dioscorides' *De Medicina*, A. D. 200. This inclusion, along with others of similar types, are meant to introduce a humanistic connotation to the descriptive materials. Many botanists will be surprised to see that only a little over two pages is devoted to *Puccinia graminis*. This does not prevent, however, introducing most of the rather involved terminology and complications of life cycle of the wheat rust.

The lower vascular plants are introduced in a novel way. After the introductory paragraphs, five problems are posed as representing those that plants must have overcome before the land could be invaded, presumably during pre-Devonian times. These were, protection from water loss, gas exchange, conduction of food and water, support of above-ground parts, and sexual reproduction. This discussion is followed by descriptions of vascular tissue, especially as found in the four major types of vascular tissue arrangement. Then, the primitive vacular plants *Psilotum*, *Lycopodium*, etc. are discussed.

The final section of the text deals with Angiosperms and a summary of evolution. The "family tree of Angiosperms" is presented here, with an unusual contradiction given in the chapter dealing with the "The Dicotyledonae." Dr. Russell discusses the characteristic features of primitive Angiosperms, versus advanced ones, following the Bentham and Hooker, and Besseyan systems. Primitive flowers present both sepals and petals, and they are unfused. The advanced flowers have neither sepals nor petals. The diagram of the "family tree" however, derives the polypetalae from the apetalae, along the lines of now largely discarded Englerian concepts. This will no doubt give the student something to think about! The Dicotyledoneae are described and illustrated, with short discussions of Ranunculaceae, Rosaceae, Leguminosae, Labiatae, Cruciferae, Umbelliferae, and Compositae. The Monocotyledoneae are then dealt with, exemplified by Gramineae, Cyperaceae, Palmae, Liliaceae, Amaryllidaceae, Iridaceae, and Orchidaceae. Both of these chapters are preceded by an account of Angiosperm structure, function, and life history. They are precisely the subjects emphasized in the usual first course in elementary botany. Dr. Russell gives 32 pages to these topics. By comparison 257 pages are thought necessary in Robbins, Weier, and Stocking's *Botany, an Introduction to Plant Science* (John Wiley and Sons, Inc., 1957). This will give fair measure of the degree of compression that has been done by Dr. Russell. Although a very brief section is given over to root, stem, and leaf anatomy—merely a gesture—this does not pre-

vent the use of such terms as protostele, osmotic gradients, dictyostele, and ectophloic siphonostele. Obviously, topics in photosynthesis, transpiration, digestion, and respiration should not be mentioned at all in this kind of coverage. They are subjects that do not lend themselves to condensation without losing most of the explanation.

The final chapter involves chiefly the traditional approach of describing life in the geological ages in sequence. It is the final chapter of the text that strikes me as being the least satisfying. The initial statement here, that the first-living organisms to appear on the earth's surface had to be plants, is certainly open to dispute. If they were plants, they surely had appearances and physiological adaptations very different from present-day plants. Perhaps primordial life was more like a primitive protozoan, rather than a primitive alga—that is, heterotrophs that assimilated less highly organized globules of material than themselves. If spontaneous generation was the means of the origin of life, then very possibly there were large amounts of complex compounds, not yet on the threshold of life, but capable, if absorbed of being utilized by the primitive heterotroph. The chemistry of photosynthesis is so extremely complex it is difficult to imagine this process was among the first life activities to have evolved.

In summary, here is a text that has been written for the general liberal arts student (as opposed to the pre-professional student) that has both strong and weak features. The overall impression one gets in studying the book is that it contains many good ideas for presenting the material in an interesting way. Dr. Russell's style of writing is not stilted, nor overly terse, hence the student would find the book quite readable. The workmanship, printing, and reproduction are of high quality. It appears to this reviewer, however, that the material in this text was rather hastily assembled, and there is about it a certain unevenness. The fundamental question which the text of this kind raises is whether or not the "survey of the plant kingdom" can be profitably used to introduce the college student to plants. Granted that this approach is more interesting to the typical student, one must admit that without the details of structure, function, and reproduction in seed plants which most elementary botany students study in the first botany course, treatment of the plant kingdom must be superficial in certain areas. For instance, how can a student grasp the tremendous importance of fungi unless he knows something about photosynthesis, cell structure, and digestion.

A second question raised is to what degree can elementary botany be compressed, and be made "non-professional"? Some botany instructors are dismayed at the size, detail, and comprehensiveness of many recently published texts. Surely these kinds of books aren't necessary for the general arts students. Dr. Russell's text is, perhaps, a good example of the extent to which condensation can be done. For that reason, the book is worthy of trial, at least.—*Robert W. Long, Dept. of Botany, Ohio Wesleyan University, Delaware, Ohio.*

Spring Flora of the Dallas-Fort Worth Area, Texas. Lloyd H. Shinners. 1958.[1] Pp. v, 514. Published and sold by the author, S.M.U. Box 473, Dallas 5, Texas, U.S.A., for $5.75.

The body of this text comprises some 410 pages. This is followed by 11 pages of line drawings and the final 33 pages (excluding the index) are devoted to appendixes. It is this final portion that makes interesting reading. Indeed it is this portion of the

[1] First copies mailed 3 April 1958; total printing was 910 copies (not counting several defective ones).—Editor's note.

book that should be read first; it is only with such a background that the reader, amateur or professional, can truly appreciate the sacrifice, frustration, experience and dedication, that have gone into the taxonomic portion. Shinners' cynicism and scathing remarks about the state of botany and botanists of this day and age often read like excerpts from Philip Wylie. Sample statements are:

"Most of them [professional biologists] do not know how to pronounce Latin names, and still entertain fuzzy and naive ideas about 'splitters and lumpers', 'useles' name-changes, and such-like mythology, which either lost what little foundation it had 25 years ago, or never did have any."

"Today the worst enemies of botany are the professional botanists. Since the sophisticated fads of the day receive too much attention already, in print and out, I shall say nothing about microscope-botany here."

Even the amateur is not spared: "Garden clubs, which could be doing solidly useful work, fritter away their energies on artificial redbud trails. Good intentions abound, but the prevailing ignorance is colossal."

Et cetera.

Though the cost of publication has been borne by Shinners, it seems unnecessary to have devoted so much of its space to sound the personal opinions of its author. Perhaps these are the privileges of one who becomes author, editor and publisher, but they are hardly less tasteful to the dispassionate reader who is seeking objectivity and detachment in a supposedly scientific endeavour.

However one might feel about such matters, some of Shinners' appendixes are masterpieces of exposition. I do not know of any book or published article that gives a better account of how to use a key, pronounce scientific names or collect herbarium specimens, than does this text. The author knows what to say and says it clearly.

But as a flora the book must stand or fall on the merits of its taxonomic treatment. Shinners is unquestionably familiar with his plants, both in the field and in the herbarium. As a handbook for the names of spring flowering plants recognized by the author for the area covered, this text is indespensable. But one would hope that, after admitting to 13 years of work on the treatment, the keys to species ought to "run." Especially after the author specifically cautions his readers (p. 441) "Trust the key—not preconceived ideas of your own. (This directed especially to those who have had botannical training.)" Because the text appeared later in the spring than anticipated, my taxonomic class was perhaps not able to give it a fair test, but it seems worth noting that 8 of 40 plants (selected because of their inclusion in the flora) could not be keyed to species, mostly because of errors in the key to families. The professional taxonomist, who usually knows most of the families, won't be bothered by these oversights, but the beginning student will often wonder if he is "incompetent" or merely "a victim of modern education" since Shinners states in his preface "Do not assume you are incompetent merely because you find technical terms and names strange and your first attempts at identifying difficult or a failure. You are probably only a victim of modern American education along with inexperience." (For those educationalists who might be miffed by such a remark there might be some solace in noting that Shinners dedicates his book to "The Dallas Teachers Credit Union whose kind assistance made it possible to complete and publish this book.")

The body of the text is replete with omissions, misspellings (certainly all typographical), oversights, etc. This is most unfortunate. Having worked under Dr. Shinners' tutelage for a master's degree I know his demand for accuracy and perfection. One can only appreciate more his statement in defense of the botanist (ob-

viously a taxonomist): "There are too few, there is too much for them to do, and at only one institution in the entire state are there really adequate facilities for the elementary job of writing a flora." He did not name the institution.—*B. L. Turner, Botany Department, University of Texas, Austin 12, Texas.*

SPRING FLORA OF CENTRAL OKLAHOMA. George J. Goodman. v+ 126 pp. (as numbered, on one side of each sheet only, the other blank), 8½ x 11 inches; paper cover, spiral-bound. University of Oklahoma Duplicating Service, Norman. $3.35.

This is a light-weight book, but a useful, competent, and much-needed one. The bulk of it consists of indented, original keys, greatly simplified (most leads use a single character only), and except for some parts which require fruits and flowers both, very easily followed. No descriptions are given for families and genera, and most species are merely listed with very little or no comment. For some there are brief notes on distribution or abundance, or some peculiarity aiding in recognition. A limited number of scientific synonyms are given, common names are added when such exist, and native region is stated for introduced plants. There is an index to families (by both Latin and English names) at the front of the book, and a glossary at the end. There are no illustrations except for the drawing of *Hymenoxys (Tetraneuris) linearifolia* on the front cover, and a county-outline map of Oklahoma on which the area covered by the Flora is outlined.

Much less pretentious than Stemen and Myers' *Spring Flora of Oklahoma with Key* (1929), and happily owing nothing to it, Goodman's book is of altogether different and much superior calibre. Instead of being largely plagiarized from Small or other alien sources, it is an original piece of work throughout. Though nothing is stated about the background, its bases include a large herbarium, extensive field work, and due attention to recent technical publications. A special word of praise is due for the inclusion of grasses, sedges, and rushes, contrary to the common, objectionable custom of spring floras. Nomenclature is generally up-to-date and accurate, but there are exceptions. Sometimes these are due to what Fernald called "following the wrong culture-hero," as for example *Thelesperma intermedium* var. *rubrodiscum* Shinners (which should be *T. filifolium* (Hook.) Gray). Again, although the category of variety is used in its traditional sense nearly throughout the book, under *Asclepias* we find the kind of thing that is rapidly producing havoc in a nomenclature which seemed well started on the road to stability: the use of the term subspecies for the same concept. Under *Houstonia* we find under no. 2: "Hedyotis rosea Raf. (This species has not yet been transferred to Houstonia.)" This is really carrying casualness too far. If the professional taxonomist, whose business it is to do so, will not clear up these trivial matters, who will?

The keys are perhaps sometimes more simple than the plants which they treat; yet for the introductory level at which the book is written, they are quite acceptable. The glossary, like the keys, is simplified, but contains such terms as *funiculus*, *helicoid*, and *syncarpous*, which surely could be dispensed with when simplicity is desired. *Phyllary* and *tepal* are two very useful terms which could well have been included but were not. Purists will quibble about the phrase *inferior fruit*, but hardly to any useful purpose. The definition of *carpel* ("a megasporophyll; a unit of a compound pistil") is in the first part unintelligible except to those so learned

as to need no definition, and in the second part barely half true. *Vein* is defined as "a vascular strand," but the esoteric term *vascular* is itself nowhere explained.

Taxonomically questionable items are remarkably few, and usually appear in groups which still need monographic study. For example, I think it unlikely that the European *Lepidium densiflorum* and *L. ruderale* really belong (contrariwise the native *L. austrinum* should have been included; I have myself collected it in Caddo and Cotton counties, in the southern part of the area which the book covers). *Matelea decipiens* I very strongly suspect is really *M. gonocarpa* (usually kept in *Gonolobus*), which is fairly widespread in north-central Texas. *Pyrrhopappus Geiseri* is common in the area but not mentioned, and the key (to *P. carolinianus* and *P. grandiflorus* only) will not accommodate plants referred there if it is not accepted as a distinct species.

A prime function of professional taxonomy is to make organisms accessible to non-professionals. This function has been well discharged by Dr. Goodman's book, within its modest limits. But it goes no farther than to open the door; we are given almost none of the details of information about the plants which a real flora ought to include. It is greatly to be hoped that there will be a second edition before long, and that it will have a much amplified text.—*Lloyd H. Shinners, Southern Methodist University, Dallas 5, Texas.*

NOTE ON THE EDITING OF THIS VOLUME

The undersigned have completed the editing of this volume after receipt of galley proof because of Dr. Shinner's resignation as editor.

W. F. Blair
Clark Hubbs
B. L. Turner
M. R. Wheeler

INFORMATION FOR CONTRIBUTORS

THE SOUTHWESTERN NATURALIST is open to papers dealing largely or exclusively with the natural history of the Southwestern United States and Mexico. Articles or notes in English or Spanish on the taxonomy, geography, ecology, and evolution of living or fossil organisms of the region are acceptable, as are bibliographical, historical, and biographical articles which contribute to investigations in these fields. Priority is given to manuscripts submitted by members of the Association.

There are no size restrictions on manuscripts, but because of high printing costs, very few long papers and not many illustrations or tables can be published unless subsidized by the author. Manuscripts should be typed, double-spaced, on one side of the paper only, with ample margins. Illustrations, maps, tables should be kept separate, mailed flat, mounted on stiff paper or cardboard, preferably not larger than 8½ by 11 inches. Legends for them should be typed on a page by themselves. Include a scale as part of any drawing for which exact size is critical.

Titles should be brief but sufficiently indicative to permit ready indexing by principal subjects without the necessity of reading the entire paper. They should be suitable for translation into foreign languages. Mention family, order, or other higher taxon with scientific names if these are part of the title. Full length articles should include an abstract. Do not use footnotes if at all avoidable. Give scientific names for all organisms mentioned. List references together at end of article, alphabetically by author, several by one author chronologically. Arrange title, author(s) with mailing address, abstract, body of paper, and references in that order.

Reprints are furnished at cost, and may be ordered when proofs are returned. No free copies of the journal are supplied to authors.

Address manuscripts and inquiries to:

DONALD TINKLE
Biology Department
Texas Technological College
Lubbock, Texas

CONTENTS

General

Man as a dispersal agent. *F. R. Fosberg* 1

Zoology

Fire ants, heptachlor, and fish kill. *Jack Boudreaux, Kirk Strawn, and Gerald Callas* 7

Fluctuations of some central Texas fish populations. *Clark Hubbs and William F. Hettler* 13

Some pleistocene amphibians and reptiles from Friesenhahn Cave, Texas. *John S. Mecham* 17

Observations on amphibians and reptiles of the Big Bend Region of Texas. *Sherman A. Minton, Jr.* 28

Variations in the mouth parts in tadpoles of *Scaphiopus (Spea) bombifrons* Cope (Amphibia: Salientia). *Arthur N. Bragg and William N. Bragg* 55

Female reaction to the male call in two anurans (Amphibia). *Ralph W. Axtell* 70

Call structure and species groups in U. S. treefrogs *(Hyla). W. Frank Blair* 77

Sleeping habits of the eastern fence lizard, *Sceloporus undulatus hyacinthinus* (Sauria, Ignanidae). *J. P. Kennedy* 90

Cnemidophorus tigris variolosus, a revived subspecies of whiptail lizard Mexico. *Richard G. Zweifel.* 94

Some observations of Texas cave bats. *Gerald G. Raun and James K. Baker* 102

Spatial organization in a population of Nelson pocket mouse. *Keith L. Dixon* 107

Botany

Some bryophytes from Baja California. *Howard Crum and William C. Steere* 114

An analysis of the grass vegetation of Texas. *T. W. Box and F. W. Gould* 124

Three chromosome numbers for *Claytonia virginica* (Portulacaceae). *Walter W. Lewis* 130

Studies in the Capparidaceae—V. Capparidaceae of New Mexico. *Hugh H. Iltis* 133

A monograph of the genus *Rosa* in North America. II. *R. foliolosa. Walter H. Lewis* 145

A monograph of the genus *Rosa in North America. III. R. setigera. Walter H. Lewis* 154

The Texas species of *Croton* (Euphorbiaceae). *Marshall C. Johnston* . 175

Chromosomes of east Texas *Hedyotis* (Rubiaceae). *Walter H. Lewis* . 204

Hedyotis australis (Rubiaceae), a new species from the south central United States. *Walter H. Lewis and Dwight M. Moore* 208

Notes (Botany)

The Mediterranean lichen *Parmelia perreticulata* in central Texas. *Mason E. Hale, Jr.* 212

Transfers from *Andropogon* to *Bothriochloa* (Gramineae). *F. W. Gould* 212

Arabidopsis thaliana (L.) Heynhold (Cruciferae) introduced in northeastern Texas. *Lloyd H. Shinners* 213

New varietal names in *Argemone* (Papaveraceae). *Lloyd H. Shinners* 213
Rosa setigera f. *alba* a form of var. *tomentosa*. *Walter H. Lewis* . . 214
Chromosome numbers for *Ampelopsis arborea* (Vitaceae) and *Linaria texana* (Scrophulariaceae). *Walter H. Lewis* 214
Callirhoe Bushii (Malvaceae) a variety of *C. papaver*. *U. T. Waterfall* 215
Solanum campechiense L. (Solanaceae) in extreme southern Texas. *Marshall C. Johnston* 216
Mimulus floribundus Dougl. (Scrophulariaceae) in Arkansas. *Dwight M. Moore* 217
Dyssodia Gentryi M. C. Johnston (Compositae), new species. *Marshall C. Johnston* 219
Carduus nutans L. (Compositae), a European thistle in northwestern Louisiana. *Lloyd H. Shinners* 220
Carthamus lanatus L. var. *baeticus* (Boissier & Reuter) P. Continho (Compositae): another introduced thistle in central Texas. *Lloyd H. Shinners* 220

Notes (Zoology)

Plastic materials for simplified tent and funnel traps. *James E. Sublette and J. S. Dendy* 220
A new record of the oligochaete *Branchiura sowerbyi* from Oklahoma. *Kenneth J. Evans* 223
Notes on Oklahoma snails (Gastropoda), with new records. *Branley A. Branson* 224
Cicadas caught by dragon flies. *Arthur N. Bragg* 226
Mississippi silversides *(Menidia audens)* instead of broog silversides *(Labidesthes sicculus)*: a correction. *Walter W. Dalquest* . . . 227
Species distribution in a mixed *Scaphiopus-Bufo* breeding chorus. *Wayne H. McAlister* 227
Clasping reflex observed in juvenile spadefoots. *Arthur N. Bragg* . . 229
A melanistic tendency in the Great Plains toad, *Bufo cognatus*. *Arthur N. Bragg* 229
The Texas slider *(Pseudemys floridana texana)* in New Mexico. *John M. Legler* 230
The ground snake, *Sonora episcopa*, in Arkansas. *Herndon G. Dowling* 231
An unusually long rattle string in *Crotalus atrox* (Serpentes: Crotalidae). *Howard Campbell* 233
Record of the hermit warbler, *Dendroica occidentalis*, in New Mexico. *Richard F. Johnston* 233
Abundance of the Palo Duro mouse *Peromyscus comanche* during 1949–1956. *J. R. Tamsitt* 234
Notes on the porcupine *(Erethizon dorsatum)* in Texas. *William W. Milstead and Donald W. Tinkle* 236

Reviews

Guide to the Families of Mites, by Baker. *R. W. Strandtmann* . . . 238
A Field Guide to Reptiles and Amphibians of the United States and Canada East of the 100th Meridian, by Conant. *J. P. Kennedy* . . 239
An Introduction to the Plant Kingdom, by Russell. *Robert W. Long* . . 240
Spring Flora of the Dallas-Fort Worth Area, Texas, by Shinners. *B. L. Turner* 243
Spring Flora of central Oklahoma, by Goodman, *Lloyd H Shinners* . . 245